WSDOT
Mobility Project Prioritization Process

Benefit / Cost Software
User's Guide

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Introduction and Background

This document provides software users with the background, assumptions, methodologies, and procedures used by the Highway Mobility Division of the Washington State Department of Transportation (WSDOT) to estimate benefit-cost criteria of proposed projects as part of the Mobility Project Prioritization Process (MPPP).

The purpose of the Mobility Project Prioritization Process Benefit-Cost software (MPPPbc.xls) is to estimate specific project's cost-efficiency. Cost-efficiency makes up 65% of the evaluation criteria, and is estimated by a user benefit / cost ratio for the life cycle of the project (usually 20 years). Benefits are estimated based on annual 24-hour user travel time savings. Costs include right-of-way, engineering, construction, and operation and maintenance. The results of the software, along with other evaluation criteria, are input into a program called TOPSIS to prioritize WSDOT highway mobility projects.

This Users Guide should be distributed to all software users. Included is a brief overview of the overall project prioritization process, (including Year 2000 changes to the benefit/cost software) a description of the benefit-cost calculations, global variable assumptions used throughout the software, and instructions on how to use the Mobility Project Prioritization Process Benefit-Cost software (MPPPbc.xls).

The Mobility Prioritization Process

Each biennium, highway mobility projects are submitted for prioritization by each of the six regions in the State of Washington. The goal of the mobility prioritization process is to differentiate among projects enough to choose the group of projects that will produce maximum “value”[1] and to justify program tradeoffs under budget constraints. Mobility project prioritization is based on the assumption that every project submitted is the best design alternative for each particular site.

The prioritization methodology consists of three primary components:

1. screening criteria,
2. evaluation criteria, and
3. a mathematical ranging algorithm.

WSDOT regional staff is responsible for evaluating every project before its submission to the statewide prioritization process. Headquarters’ staff serves primarily as technical support

[1] The term value, as used here, is meant to encompass all the benefits of transportation improvements, including those that are not typically assigned a dollar value.

during the evaluation process and review calculations for accuracy. They also perform the mathematical ranking of projects.

Screening Criteria

The Systems Plan, with its defined financial constraints for highway improvements, functions as the first screening criterion. Project requests not contained in the Systems Plan are ineligible for further prioritization. Because the state highway systems plan must guarantee conformity to air quality requirements, any proposal that would worsen air quality in a non-attainment area would also fail the initial screening. A further expectation for the 1995-1997 and future programming cycles was that project submittals would focus only on existing deficiencies, except as otherwise requested by outside agencies such as metropolitan planning or regional transportation planning organizations.

Evaluation Criteria

Table 1 shows the seven criteria that are used for Mobility project evaluation, along with their relative weights. The criteria categories, scoring procedures, and weights were established with extensive input from state transportation officials and WSDOT personnel.

Each of the seven criteria is briefly described in the following sections.

Table 1. Criteria and Weights for the 1995-1997 Biennium

Category	Weight
1. Cost-efficiency	65%
2. Community Support	14%
Environment	8%
3. Wetlands	
4. Water Quality and Permitting	
5. Noise	
6. Modal Integration	7%
7. Land Use	6%
TOTAL	100%

Benefit/Cost (B/C) Ratio or Cost-efficiency

The cost-efficiency of a project is measured by the benefit/cost ratio, which is the present value of the monetized project benefits divided by the project costs. In this category, projects with higher scores are more favorable. The basic equation for the benefit/cost ratio is:

$$B/C = \frac{PV_B}{PV_C}$$

where:

B/C = benefit/cost ratio

PV_B = present value of the project’s benefits

PV_C = present value of the project’s costs

The benefit categories consist of:

- travel time savings for passenger and freight movement,
- user operating savings, and
- accident reduction (safety).

The cost categories consist of:

- construction,
- environmental retrofit,
- preliminary engineering, and
- annual operating and maintenance.

Community Support

The community support category consists primarily of yes/no questions that assess financial participation, endorsement, and opposition by local governments, local organizations, and private groups or individuals. This criterion also addresses potential disruption of neighborhoods and displacement of homes, businesses, or farm land. In this category, projects with lower scores are more favorable.

Wetlands Assessment

This category assesses the intrusion of proposed projects upon classified wetlands and associated buffer areas in accordance with federal, state and local regulations. Since mitigation costs are already included in the construction cost estimate, this category seeks to reflect the magnitude of public resistance to wetland impacts. It considers the acreage of any wetlands within 300 feet of proposed projects and assigns penalty points weighted according to the classification of the encroached wetlands. In this category, projects with lower scores are more favorable.

Water Quality and Permitting

This category assesses potential impacts on the acreage of impervious surface area within 2,000 feet of any body of water. Analysis consists of yes/no questions primarily regarding the number and nature of permitting requirements for a proposed project. The subtotal score reflects the magnitude of permitting requirements and is divided in half if no foreseeable permitting conflicts exist. In this category, projects with lower scores are more favorable.

Noise Assessment

This category assesses the potential noise impacts for a proposed project. Points are accrued on the basis of a calculated “risk factor,” which is based on the number of lanes for the proposed project, as well as the number of noise receptors and their proximity to that project. Risk factor points are weighted twice as heavily for new projects as they are for improvements to existing projects. In this category, projects with lower scores are more favorable.

Modal Integration

The purpose of this criterion is to assess the level of modal integration supported by a proposed project in accordance with Washington State policy goals. This category consists of yes/no questions concerning efficient use of existing capacity, connectivity between existing systems, integration of alternative modes such as bicycling and walking, and "multimodally" packaged projects. In this category, projects with lower scores are more favorable.

Land Use

This category assesses the support that proposed projects provide for Washington State mobility and land-use management objectives. Land-use criteria consist of yes/no questions concerning coordination between WSDOT engineers and planners, provision of convenient accessibility to transit, connectivity between urban activity centers, and consistency with regional and local comprehensive and/or transportation plans. In this category, projects with higher scores are more favorable.

The TOPSIS Ranking Process

Once proposed projects have been screened, evaluated, and scored in the seven criteria categories, they are ranked with a mathematical ranking procedure[2]. The projects are compiled into an evaluation matrix in which the rows define the different projects to be ranked and the columns contain the seven criteria categories. The algorithm used to rank projects, called TOPSIS, allows elements with disparate units (in this case, projects with disparate criteria) to be easily evaluated.

The premise of TOPSIS is that it:

- normalizes the scores in an evaluation matrix into dimensionless units;
- multiplies each of the scores by their relative assigned weights;
- formulates a theoretical "ideal-best" project and a theoretical "ideal-worst" project;
- prioritizes proposed projects by calculating their relative distances between the ideal solutions.

The theoretical "ideal-best" project is determined by combining all of the best scores in each of the separate criteria categories. The "ideal-worst" project is determined by combining all of the best scores in each of the criteria categories. TOPSIS is based on the concept that the chosen alternative should be closest to the ideal-best solution and farthest from the ideal-worst solution.

In our review of the TOPSIS process performed in 1996, we found that B/C ratios have ranged from under 1 to nearly 225 for urban projects and to just over 10 for rural projects. Nearly 72% of rural projects have B/C ratios under 5 versus urban projects of which 54% are under 5.

[2] Note: The current project ranking methodology includes a step to modify B/C ratios output from the MPPP B/C software prior to input into the TOPSIS program. The purpose of this additional step is to account for environmental retrofit benefits.

Year 2000 Review of WSDOT Benefit Estimation Methodology

In 1999 and 2000, a consultant team led by Dowling Associates conducted an extensive review of the WSDOT benefit estimation methodologies. The methodologies were compared to recent work by the Federal Highway Administration and the State of Florida on the economic evaluation of highway improvement projects. Recent research by the consultant team on transit operations, HOV lane demand, and travel time prediction were also brought into the evaluation. The Draft Year 2000 Highway Capacity Manual was consulted for the most recent information on speed-flow relationships. Recent National Cooperative Highway Research Program (NCHRP) research was consulted for information on the effects of Two-Way Left Turn Lanes (TWLTL) on delays and capacities.

It was concluded from the evaluation that the basic analysis philosophy used by WSDOT was quite sound. It reflects the state of the art in economic evaluation and is consistent with and comparable to the economic evaluation methods used by FHWA and other state agencies. Nevertheless, there were several opportunities for improving specific components within the WSDOT methodology, including major improvements to the HOV, TWLTL, and park & ride analysis methods to take advantage of recent research in these areas.

Year 2000 Software Modifications

Addition or Modification of Worksheets

- Addition of a Software Notes worksheet
- Addition of a Global Variables worksheet for default values that previously had been hardwired in the software. Worksheet allows user to define:
  - discount rate
  - project life cycle
  - benefit days per year
  - cost parameter values of time and operating costs
  - population density and AVOs
  - ADT hourly distribution curve
  - start, end, and number of hours in the AM and PM peak periods
  - ratio of benefits for new users
- Addition of a 24-Volume Distribution Chart
- Addition of a 4-Step Model worksheet to estimate user benefits from 4-step model output
- Modifications to the Two Way Left Turn Lane (TWLTL) worksheet
- Overhaul of the HOV benefit worksheet
- Addition and modification of a Park & Ride worksheet

Changes to Speed-flow Curves

- Moved the WSDOT Default speed-flow curves to a separate worksheet so it could be consistently used throughout the workbook

- Added the option of using the HCM 2000 freeway curves in the HOV worksheet and the Freeway worksheet

Conversion of Peak Hour to 24-hour Benefits

- Provided means for converting working peak hour benefits to 24-hour benefits in the TWLTL and Interchange worksheets

User Interface and Maintenance Improvements

- Removed hardwiring of many variables including AVOs, cost parameters, days per year, peak period percentages, discount rates, length of analysis, etc.

- Added notes, comments, and assumptions

- Invoked a variable naming protocol

- Set up print areas with consistent headers and footers

Overview of WSDOT Benefit/Cost Methodology

This section describes the current WSDOT methodology used to estimate the user benefits associated with individual proposed projects. This includes procedures used to forecast demand, estimate travel time savings, and calculate user benefits. Additionally, a section is provided that describes the sensitivity of the methodology to the data inputs and global variables.

Demand Forecasting

The calculation of a project's user benefits includes both travel time savings and user operator savings. These components are dependent upon the number of users receiving the benefit. The number of users is estimated from actual traffic counts and volume projections of single-occupancy vehicles (SOV), high-occupancy vehicles (HOV), and trucks, the percentage of the overall traffic flow using these modes, and their associated average vehicle occupancies (AVO).

Available Traffic Volume Data

The user must determine the best available traffic data for use in the spreadsheets. Most worksheets require enough traffic volume data to be input to estimate average weekday daily traffic (AWDT) volumes. Base year count data may have been collected by the individual regions, or in some cases may be obtained from the TDO Travel Analysis Section of the WSDOT. The estimated future year volumes, and even build vs. no build volumes, may be available from MPO long-range forecasts, route corridor plans, developer impact documents, or other acceptable traffic analyses. If design hour volumes (DHV) are used from design reports, then appropriate "K" reduction factors must be applied prior to input into the worksheets. These factors may be obtained from the TDO Travel Analysis Section of the WSDOT. However, in the absence of these data sources, Year 1 and Year 20 volumes are estimated as described below.

Growth Rates and Volume Projections

In general, when Year 1 or Year 20 volumes are not known, they are extrapolated from available data using a straight-line growth method. The straight-line growth method assumes the same total change in volume annually for a given number of years.

For example,

*Year 1 Volumes = Present Year Volumes * (1 + Growth Rate)*

*Year 20 Volumes = Year 1 Volumes * (1 + Growth Rate * 20)*

Year 1 volumes are estimated by applying current growth rates in the area. This growth rate information is available from the TDO. Future rates of growth (or current rates in some rural areas) are applied to calculate Year 20 volumes. The user inputs the growth rate to be used in the analysis into the applicable worksheet.

It should be noted that all worksheets (except the HOV Lane worksheet) use the same demand volumes for both the build and no-build conditions, although the peak spreading routine does allow for different redistribution of the volumes over the 24-hour period based on available capacity. The two-way-left-turn worksheet does not have a peak spreading routine and thus the same volumes are used for build and no build analyses. The intersection worksheet allows a user to reduce or increase the no build demand volumes by approach.

Expansion of One Hour Demand to 24-Hour Demand

The worksheets used to determine the benefits of adding lanes (General Purpose, Climbing, or HOV) and the Intersection Benefits worksheet use a selected ADT volume distribution curve to estimate benefits by each hour of its 24-hour period, by direction and approach, respectively. If each of the 24 hourly volumes is known, the user can input these volumes into the Curve~Data.xls worksheet and the resultant calculated hourly percentages will be available for selection in the MPPPbc.xls software. If 24-hour volume distribution is unknown, several sample distribution curves are provided in Curve~Data.xls from which users can select.

A couple of the worksheets (TWLTL and Interchange) rely on use of working peak hour volumes to determine user benefits. In these worksheets, the selected 24-hour volume distribution curve is used to estimate a relationship between peak hour and 24 hour user benefits.

Capacity Constraint and Peak Spreading

In the worksheets where volumes are distributed to each hour of a 24-hour period, a calculation is performed to determine over-capacity conditions for any specific hour of the Year 20 no build and build scenarios. If over-capacity conditions exist, demand volumes are reallocated to other hours.

The worksheets estimating the benefits of adding a lane (General Purpose, Climbing, or HOV) prevent any one hour volume from exceeding the hourly capacity of the facility by a specific amount (i.e. a maximum v/c of 1.2 for general purpose and climbing lanes, and 1.0 for HOV lanes). The hourly capacity of the facility is calculated by multiplying the ideal capacity per lane by the number of lanes and then adjusting it based on the percent trucks and length of grade.

The intersection benefit worksheet prevents any one hour's total approach volume from exceeding the total intersection capacity. The total intersection capacity is calculated by dividing the intersection peak hour volume by the intersection peak hour v/c ratio, effectively constraining the volume to a maximum of v/c of 1.0.

In each of the worksheets that include a capacity constraint, if an hourly volume (hour i) is found to exceed the maximum allowed as described above, the excess hourly volume is added to the hour before (hour i-1) (if the hour is before 5 PM) and to the hour after (hour+1) (if the hour is after 5 PM). The result is a “flattening” of the 24-hour distribution curve, or “spreading” of the peak hour. The volumes representing the flattened curve are then used to calculate hourly v/c’s for each of the 24 hours, and these v/c ratios are constrained to the maximums described above.

The HOV and two-way left turn lane worksheets assume that the excess demand (that portion which exceeds capacity) queues up at the entrance to the link, and a delay estimation procedure is used to calculate travel times under over-capacity conditions (see section on TWLTL and HOV Lane Queuing Delay Estimation on page 11).

Traffic Mix

The user inputs information relating to traffic mix in the form of truck percentages and HOV percentages.

Truck Percentages

The peak hour truck percentages for an average weekday peak hour are available in the TRIPS History File for most projects. Unless more detailed truck percentages are available, the same truck percentage is used for Year 1 and Year 20 computations.

HOV Percentages

HOV peak hour percentages are input for use in the Two Way Left Turn Lane analyses, and much more detailed vehicle mix information is provided for HOV analyses. See specific descriptions of these worksheets for more details.

Travel Time Savings Estimation

This section provides an overview of the methodology used to estimate the travel time savings for each mobility project.

Overview of Method

For most worksheets the travel time savings is the computed difference in vehicle-hours travel time with and without the project. The ratio of demand to capacity is computed for each analysis year both with and without the proposed project. The mean travel speed for each year and project scenario is obtained from a look-up table of speeds and volume/capacity ratios. The mean speed is divided into the length of the facility to obtain the mean travel time. The mean travel time is multiplied by the volume to obtain vehicle-hours travel time for each project scenario. For intersection improvements, the travel time savings is estimated by the change in overall delay associated with build and no build conditions.

The following subsections explain how the capacity of a facility is determined, how the mean speed is estimated, how over-capacity conditions are handled, and how travel time savings are distributed to vehicle users.

Capacity Analysis

The current WSDOT mobility prioritization methodology uses default capacity values based on the 1985 Highway Capacity Manual and Charles Fuhs' 1990 High Occupancy Vehicle (HOV) Design Manual. These base capacities are shown below.

Table 2. WSDOT Default Capacities Used in MPPPbc Software

Facility Type	**Capacity (vphpl)**
Urban Freeway	2,200
Rural Freeway	2,000
Urban Multi-lane Highway	2,200
Rural Multi-lane Highway	None
Rural Two-lane Highway	1,400
Arterial	1,600
HOV Lane	1,500

The capacity values are generally consistent with the current (1997) edition of the Highway Capacity Manual, with the possible exception of the 1600 vehicles per hour per lane capacity used for Arterials. If the term "Arterial", as used by WSDOT, applies only to state highways in urban areas with no signals, then the WSDOT capacity value is probably satisfactory. However, if there are signals present on the arterial, then the facility is more like an arterial street. Arterial streets typically have capacities of 800 to 1000 vehicles per hour per lane, after taking into account the capacity losses caused by signal timing.

Mean Operating Speed Estimation

The current WSDOT mobility prioritization software uses look-up tables taken from the second edition of the Traffic Engineering Handbook to estimate mean link speeds (see section on WSDOT Default Speed-Volume Tables). These tables vary by facility type and the posted speed limit. These tables go up to a demand/capacity ratio of 1.2.

If the v/c ratio is greater than 1.00, then the WSDOT software uses a special equation to compute the delay associated with the excess demand (see next section below).

Over Capacity Conditions

Depending on the facility type, the WSDOT methodology either caps the maximum demand at a pre-selected v/c ratio and reallocates the excess demand to other hours of the day, or it computes the delay caused by the excess demand.

Addition of General Purpose Lanes

For projects involving the addition of a "general purpose" lane to freeways, highways, or rural roads, or the addition of truck climbing lanes, the estimated hourly demand is capped at 1.20 times the capacity, (see section Capacity Constraint and Peak Spreading on page 8 for demand redistribution). The speed-flow curves used to calculate travel times provide estimates of mean operating speeds for v/c ratios up to 1.2. Travel times are calculated according to the following equation:

$$VHT = \frac{V * H * D}{S}$$

where:

VHT = Travel time (in units of vehicle hours traveled)

V = Demand (vph), capped at 1.2 times the capacity

H = Length of analysis period (hours), set to one hour in software

D = Length of study section (miles)

S = Estimated mean operating speed, determined from look-up tables.

New Interchange Projects

For interchange improvement projects, savings in travel time are estimated based on the change in delay for selected point-to-point routes during the working day peak hour. Demands are not evaluated for over-capacity conditions.

Improvements to Existing Intersections

For intersection improvement projects, estimated hourly demands are capped at the estimated capacity of the intersection as previously discussed. The capacity of the intersection is calculated to be the total approach volume divided by the overall intersection v/c ratio. Travel time savings are estimated by the overall difference in delay between the build and no build conditions.

TWLTL and HOV Lane Queuing Delay Estimation

For HOV lane analysis and two-way left turn lane analysis the WSDOT software assumes that the excess vehicles (that portion of the demand that exceeds capacity) queues up at the entrance to the link. These vehicles are delayed an average of one-half of the analysis period. All vehicles are then assumed to move through the link at a speed associated with at-capacity conditions. The equation below shows the computation of link travel time in terms of vehicle-hours of travel.

$$VHT = \frac{(V - C)}{2} * (H)^2 + \frac{V * H * D}{S}$$

where:

VHT = Travel Time (in units of vehicle hours traveled)

V = Demand (vph)

C = Capacity (vph)

H = Length of analysis period (hours), set to one hour in software

D = Length of study section (miles)

S = Speed at capacity (mph).

Distribution of Time Savings to User Categories (Trucks, HOV, SOV, GP)

The WSDOT prioritization process depends on the travel time savings and user operating cost savings benefits associated with person trips rather than vehicle trips. Therefore, the travel time savings (TTS) must be distributed to individual user categories based on estimates of truck percentages and HOV percentages if known.

In general, travel time savings are calculated by estimating the difference in total travel time under with and without project conditions, regardless of vehicle mix. Travel time savings are then distributed between trucks and general purpose (GP) lanes as follows:

$$TTS_{TRUCKS} = (\%\ trucks) * TTS_{TOTAL}$$

$$TTS_{GP} = (1 - \%\ trucks) * TTS_{TOTAL}$$

However, the analyses for adding truck climbing lanes and HOV lanes estimate travel times separately for vehicles in the general purpose lanes and the added specialized lane. Additionally, if HOV percentages are known for the two-way left turn analyses, travel times savings are estimated separately for these users.

Benefits Computation

The calculation of project benefits falls into two broad categories: 1) the present value of user benefits, and 2) the present value of safety benefits. This study is focusing only on the calculations used to determine the present value of project user benefits. Project user benefits include both travel time savings and user operator savings, as determined in the user benefits worksheets.

The following standard parameters are integral to the outcome of the benefit/cost analysis:

- Discount rate
- Project life cycle
- Value of time
- Cost parameters
- Conversion to annual user benefits
- Present value factor
- Handling of negative benefits

Discount Rate

The benefit/cost methodology utilizes the "constant dollar" approach to estimate future benefits and costs. The reason for using this approach (as opposed to the "current dollar" approach) is that it eliminates speculation about future inflation. It does this by using a discount rate that reflects only the real cost of capital, or the rate at which the money to be used in a given project could be alternatively invested. The default standard discount rate for the constant dollar approach is 4%.

Project Life Cycle and Residual Value

In addition to the discount rate, default project life cycles must be considered. The traditional project life cycle, the length of time generally used in planning and forecasting transportation projects, is 20 years. WSDOT has determined that some projects do benefit from a shorter period of analysis, but that the majority of projects are well suited to the 20-year time frame.

For projects that require a longer period of analysis, a residual value methodology is used to adjust the benefit/cost ratio to account for the value of the improvement remaining after 20 years. The residual value methodology is based on work done for AASHTO by the Texas Transportation Institute, and is done by applying the factors shown in Table 3 to the project's cost estimates.

Table 3. WSDOT Residual Value Factors

Estimate	Factor
Right-of-way	0.55
Grading and drainage	0.60
Structures	0.57
All other costs (include PE)	1.00

Value of Time and Cost Parameters

The current WSDOT methodology values saving one hour of an auto driver's time at $10 per person-hour. Reducing travel time for a truck is valued at $50.00 per vehicle-hour in both rural and urban areas. Table 1 shows that these estimates have two major components: the value of travelers' time and vehicle operating costs. This combined value is then adjusted for vehicle occupancy.

Table 4. WSDOT Assumptions Used to Estimate Travel Time Savings

User Cost Parameters		
	Autos	**Trucks**
Value of Traveler's Time		
Average Wage Rate	$18.36	$20.22
Value of In-Vehicle Time as % of Wage Rate	33%	100%
Individual Value of Travel Time Per Hour:	***$6.12***	***$20.22***
Vehicle Operating Costs		
Operating Costs per Mile	$0.07	$0.66
Average running speed (mph)	50	50
Vehicle Operating Costs Per Hour:	***$3.75***	***$32.85***
Value of One Vehicle Hour (1 Driver)	**$9.87**	**$53.07**
Hourly User Benefit-Cost Parameters:	***$10.00***	***$50.00***

The WSDOT method assumes that the value of in-vehicle time for general purpose travelers is one-third the average wage rate of $18.36 per hour.[3] For trucks, the appropriate wage rate is the hourly costs of salary and benefits for a truck driver. The value of $20.22 was developed from consultation with the Teamsters Union.

To these values of individuals' time is added the average cost of operating a vehicle traveling at 50 miles per hour. The individual time and vehicle operating costs are combined and then rounded to $10 per hour for cars and $50 for trucks.

Conversion to Annual User Benefits

The estimates of travel time savings by user are monetized as user benefits by translating travel time savings to overall user cost savings using the associated cost parameters described above. Workday travel time savings estimates are converted into annual user benefits for Year 1 and Year 20 using the following formulae:

[3] Source: WSDOT's report, *Mobility Programming Criteria and Evaluation Procedures*.

$$User\ Benefits = ((TTS_{GP} * CP_{GP}) + (TTS_T * CP_T)) * 260$$

and, if HOV percentages are known,

$$(TTSGP * CPGP) = (TTSHOV * CPHOV) + (TTSSOV * CPSOV)$$

where:

TTS_{GP} = Travel time savings (hrs) for general purpose traffic

TTS_{SOV} = Travel time savings (hrs) for SOV traffic

TTS_{HOV} = Travel time savings (hrs) for HOV traffic

TTS_T = Travel time savings (hrs) for truck traffic

CP_{GP} = Cost parameter (including operating costs) for general purpose traffic

CP_{SOV} = Cost parameter (including operating costs) for SOV traffic

CP_{HOV} = Cost parameter (including operating costs) for HOV traffic

CP_T = Cost parameter (including operating costs) for truck traffic

260 = Number of workdays per year

Present Value Factor

The final step in calculating the overall present value of the project user benefits is to determine the Present Value Factor (PVF). This factor is multiplied by the Year 1 benefits to determine both the present value of user travel time and operating savings benefits (PV_B) that is recorded in the overall cost-efficiency worksheet. The PVF assumes that annual benefits are distributed equally between Year 1 and Year 20. The PVF is calculated by first finding the ratio of Year 20 to Year 1 user benefits and then employing the following formula:

$$PVF = \frac{(e^{(r-i)n} - 1)}{(r - i)}$$

where:

r = ln(/Y (represents the annual growth rate)

= Year 20 benefits / Year 1 benefits

Y = Period of estimate (in most cases, Y = n = 20)

i = Discount rate (= 4%)

n = Analysis period (20 years)

Handling of Negative Benefits

It is important to note that the WSDOT methodology for analysis of intersection improvements does not allow negative hourly user benefits to be included in the calculation of overall present value benefits. This occurs primarily under the methodology used to analyze intersection benefits. Since the delay equation has a parameter that is positively related to the capacity of the intersection, the calculated delay for the intersection can be greater under build conditions than under no build conditions because of the improved capacity. This can result in a negative time savings and thus negative benefits. The methodology used in the worksheet checks for this condition, and zeroes out any negative benefits. If the negative benefits are estimated correctly, they should be carried through the estimation of overall user benefits. However, in this case, the negative user benefits are likely due to incorrect assumptions in the delay equation.

Sensitivity Analysis of Variables

This section presents the sensitivity of the WSDOT benefit estimation methodology to the user input or default global variables. This analysis is based on controlled changes to the inputs of the original Excel workbook's Arterial Daily Benefit Worksheet (ARTDBEN in ALLFORMS.XLS).

Tested Variables

The sensitivity analysis was performed by increasing or decreasing a selected input value, while holding all other variables constant, and noting the resultant change in overall user benefits. The following variables were tested:

- Length of Segment (miles, based on the beginning and ending mileposts)
- No Build and Build Posted Speeds
- Number of Lanes (bi-directional)
- Year 1 Volumes
- Truck Percent (%)
- Grade Percentage
- Length of Grade
- Growth Rate
- Curve Number (represents a percent ADT distribution curve)
- Average Vehicle Occupancy
- Roadway Type / Capacity
- Discount Rate

It should be noted that some of these variables are not continuous; either they must be one of a list of selected values, or they only affect the resultant benefits if above or below a certain value. For example, the posted speeds directly affect the estimated operating speeds and thus the travel time savings, but since they are assumed to be either 50 or 60 mph, the change in input cannot be continuous, say 55 mph. The posted speed is either 60 mph and above, or 50 mph and below. Another example is the combined effect of grade and length of grade. Changes in these variables only affect the benefits when the grade is greater than 3% for a length of more than one-half a mile. If both these conditions are not met, the overall user benefits are unaffected by grade or length of grade.

Analysis Results

The results of the sensitivity analysis suggest that the WSDOT benefit methodology is very sensitive to changes in

- demand volumes, and
- the percent of the demand occurring during the peak periods.

Since user benefits are highly sensitive to the input demand volumes, they are therefore also sensitive to the method used to develop demand volumes. This includes any peak hour reduction factors or K factors, the growth rate use to obtain Year 1 volumes from available traffic data, and even rounding error.

Also, the percent of the demand occurring during the peak periods, determined by the selected ADT distribution curve, significantly affects the resultant user benefits.

It is interesting to note that the user benefits estimated by the arterial benefits worksheet are not particularly sensitive to the following:

- changes in the assumed growth rate (except in how it affects the determination of Year 1 volumes outside of the worksheet),
- average vehicle occupancies (although, the two-way left turn lane and HOV analysis worksheets which allow a user to input specific HOV percentages may be more sensitive to AVOs), or
- the default discount rate of 4%.

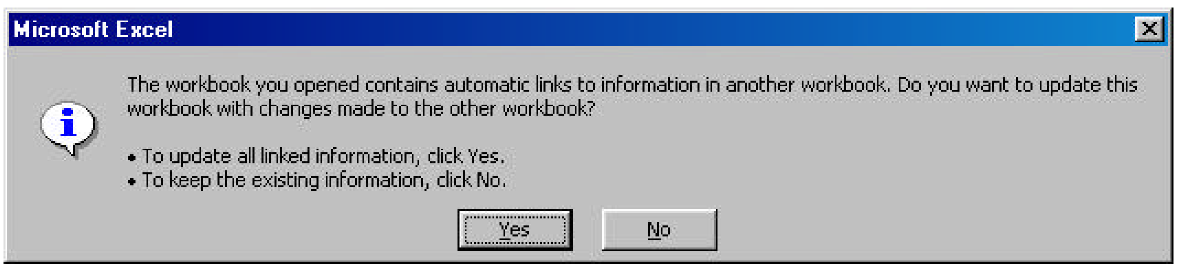
Software Notes

Installing the Software

To install the MPPPbc software, simply copy the following files into any work directory:

- MPPPbc.xls
- Curve~Data.xls

These files do not need to be in the same directory, but MPPPbc.xls must be able to link to Curve~Data.xls in order for the 24-hour volume distribution curves to be accessible. To automatically update the link between these files, after opening MPPPbc.xls in Excel, answer Yes to the update links question as shown below.



You will be prompted for the location of the Curve~Data.xls file. Browse for the file's location and click on "OK".

> *If at any time you want to open, update or change the source of the Curve~Data.xls information in MPPPbc.xls, while in Excel select the pull down menu Edit and select Links…*

Curve~Data.xls (ADT 24-hour Volume Distribution Curves)

Curve~Data.xls stores up to 200 user defined ADT hourly volume distribution curves. Users input the route number and milepost, date of count or volume estimate, and the count or volume data by hour and direction into the Input Curve Data Here worksheet.

The Read Data Here worksheet calculates the percentage of total bi-directional volumes by hour and direction. The Drop Down List worksheet creates the pull down list of curves for selection in MPPPbc.xls. These two worksheets are linked to MPPPbc.xls and contain all of the volume distribution data available for user's selection. Ultimately, the hourly volume distribution curves are used to estimate 24 hour user travel time savings benefits.

Saving Project Data

The properties of MPPPbc.xls have been set to make the workbook read-only. This protects users from overwriting data in the workbook, and changes to the workbook cannot be saved in the same workbook file. Users must save the project data by using the **Save As** command (**File** menu) to save another version of the file with a different name or in another location. All links from MPPPbc.xls to associated files (e.g. links to Curve~Data.xls) will be maintained with the new workbook with the project data.

General Color Coding in MPPPbc.xls

1. Required user inputs are denoted by a bold green outline.
2. **Black bold** and/or plain text refer to titles, captions, units, and calculated values.
3. Green text refers to user inputs and user assumptions.
4. Purple text refers to explanatory text, worksheet assumptions, notes and sources.
5. Blue text refers to values that are based on global inputs or are determined internally to the worksheet and should not be changed.
6. Red text refers to warnings and error checks.

Software Structure

The MPPPbc software is an Excel 5.0/95 workbook called MPPPbc.xls. This workbook consists of separate worksheets designed to estimate the overall cost-efficiency of different elements of a proposed project.

User Information and Project Input Worksheets

User information and project input worksheets are included to allow the user to review and/or define:

- software notes;
- a proposed project description;
- software global variables;
- a selected volume distribution curve (to convert peak hour to 24-hour benefits);
- default WSDOT speed-flow curves; and
- HCM 2000 freeway speed-flow estimates.

Project Benefit Worksheets

The project benefit worksheets that estimate the benefits of individual improvement components of the project include:

- analysis of 4-step model results;
- addition of a two way left turn lane;
- addition of a general purpose lane on an arterial or freeway;
- addition of a truck climbing lane;
- intersection improvements;
- a new interchange;
- addition of an HOV lane;
- new park & ride lots; and/or
- accident savings/safety improvements.

A new worksheet was added to the MPPPbc software that allows users to evaluate benefits using the results of an accepted 4-step model. This is a useful tool if the detailed specific data required by the worksheets for the particular improvement is not available or if modeled effects of induced demand are desired.

Worksheet Descriptions

Software Notes

Provides software's purpose, structure, and color coding scheme. Describes each of the worksheets.

Project Description

Provides a description of the proposed project, including route, posted speed, title, beginning and ending mileposts, no build and build number of lanes, terrain, and population density (urban or rural).

Global Variables

A place holder for the benefit/cost analysis assumptions and default values that are used throughout the workbook. Includes: discount rate (i), project life cycle (n), benefit days per year, a selection of ADT 24-hour distribution curves, start and end times of AM and PM peak periods, and value of time and operating costs.

24-Hour Volume Distribution Chart

Graphically displays the selected Year 1 directional and total volume distribution by hour of the day. Once the user selects or define the ADT 24-hour distribution curve in the Global Variables worksheet, the selected curve will automatically be displayed in the 24 Hour Volume Distribution chart.

Estimate and B-C Ratio

Allows user to input cost estimates for preliminary engineering, environmental retrofit, right-of-way, construction, operation & maintenance. User has the option of providing quantities needed for detailed cost calculations or general cost-per-mile estimates. User must provide non-WSDOT cost share and operation & maintenance costs, or a WSDOT present value cost (PVc). This worksheet incorporates the individually present value of user benefits for each particular improvement included in the workbook and estimates the overall benefit/cost ratio and net present value (NPV) for the project.

4 Step Model Benefits

Estimates annual 24-hour user benefits based on output from an accepted 4-step model. The worksheet can estimate user benefits for entire system if data is provided, but only benefits for state system users will be incorporated into overall project B/C ratio.

Two Way Left Turn Lane (TWLTL) and Multilane Access Management Benefits

Estimates annual 24-hour user benefits for converting a 2-lane undivided facility to a 3-lane TWLTL facility (Harwood/St. John method), OR for median treatments and/or access spacing changes for 4-7 lane facilities (NCHRP 395 method).

General Purpose Lane Benefits

Estimates annual 24-hour user benefits for adding a general purpose lane. Facilities that can be analyzed include: a 2-lane highway, an arterial, a rural/small urban freeway, or a multilane highway or freeway. Benefits are estimated by each hour of the day for the selected direction(s) of the facility.

Climbing Lane Benefits

Estimates the annual 24-hour user benefits for adding a truck climbing lane to a 2-lane highway or to an arterial. Methodology is similar to that of adding a general purpose lane. This worksheet has NOT been updated to look up values from the WSDOT speed-flow curve worksheet. WSDOT speed-flow curves are still embedded in worksheet.

Intersection Benefits

Estimates the annual 24-hour user benefits for improving an existing intersection. Benefits are estimated by each hour of the day.

New Interchange Benefits

Estimates the annual 24-hour user benefits for adding a new interchange to an existing facility. Model travel times can be input for specific O-D paths instead of being calculated based on distances and speeds.

HOV Lane Benefits

Estimates the directional annual 24-hour user benefits for adding an HOV lane. Benefits are estimated by each hour of the day for the selected direction(s) of the facility. Worksheet assumes that HOV lane is only available to HOV2+ or HOV3+ users during the defined peak period, but can be used by general purpose traffic outside of the peak period.

Park & Ride Lot Benefits

Estimates the bi-directional annual user benefits for constructing a park & ride lot. Users can input up to five (5) different destinations for each park and ride lot.

Safety Benefits

Estimates the annual 24-hour user benefits of improving the safety of a facility. User selects from a list of safety improvements and identifies the number of accidents by type of accident.

SYNCHRO

Worksheet placeholder for icon link to SYNCHRO.

WSDOT Default Curves

Contains WSDOT default speed-flow curves for 50, 60, and 70 mph facilities. Speeds are dependent upon v/c ratio and the number of lanes. HOV lane speeds are dependent upon volumes. The lowest allowed congested speed for general purpose lane speeds is 15.2 mph (for v/c >= 1.2). Allowable HOV lane speeds are 55 mph at free-flow down to 40 mph at capacity. HOV lane speeds are solely dependent upon lane volumes and an assumed capacity of 1,500 vehicles per hour.

HCM 2000 Curves

Contains the HCM 2000 speed-flow curves for freeways. Speeds are dependent upon free-flow speeds, length of segment, and v/c ratio. Freeway speeds for general purpose and HOV lanes can range from free-flow speeds down to about 12 mph at a v/c of 2.0.

Reports

The print area in the Software Notes worksheet is set up to generate a four-page report. The first page summarizes the software purpose, structure and color-coding. Pages 2-4 summarize the description, required and optional inputs and actions, and notes on each of the individual worksheets. This report is shown on the next four pages.

WSDOT Mobility Project Prioritization Process
User Benefit Software
Software Notes

Purpose of Software

The purpose of this software is to estimate specific project's cost-efficiency to be used in WSDOT's Mobility Project Prioritization Process.
Cost-efficiency makes up 65% of the evaluation criteria, and is estimated by a user benefit / cost ratio for the life cycle of the project (usually 20 years).
Costs include right-of-way, engineering, construction, and operation and maintenance. Benefits are estimated based on user travel time savings.
The results of this workbook, along with other evaluation criteria, are input into a program called TOPSIS to prioritize WSDOT highway mobility projects.

Software Structure

This workbook consists of separate worksheets that are designed to estimate the cost-efficiency of a project.
A project can consist of one or more improvements that are designed to be implemented together. All elements must be within the same milepost limits.
The Estimate and B-C Ratio worksheet incorporates a project's total costs and user benefits associated with the group of improvements.
Separate worksheets are provided to evaluate the user benefits of particular types of improvements, including:
addition of a two way left turn lane; addition of a general purpose lane on an arterial or freeway; addition of a truck climbing lane;
intersection improvements; a new interchange; addition of an HOV lane; new park & ride lots; and/or accident savings/safety improvements.
If the detailed specific data required by the worksheets for the particular improvement is not available, or if modeled effects of induced demand are desired,
a worksheet is provided that can evaluate benefits using the results of an accepted 4-step model.

General Color Coding

1) Required user inputs are denoted by a bold green outline:
2) Black **bold** and/or plain text refer to titles, captions, units, and calculated values.
3) Green text refers to user inputs and user assumptions.
4) Purple text refers to explanatory text, worksheet assumptions, notes and sources.
5) Blue text refers to values that are based on global inputs or are determined internally to the worksheet and should not be changed.
6) Red text refers to warnings and error checks.

Worksheet Descriptions

Worksheet	Description	Required Inputs / Actions	Optional Inputs	Notes / Comments
Software Notes	Provides software's purpose, structure, color coding scheme. Describes each of the worksheets.	None	None	None
Project Description	Project description.	Project description, including route, posted speed, title, beginning and ending mileposts, no build and build number of lanes, and terrain.	None	The default population density is taken from the Global Variables worksheet. Posted speeds are rounded to 50, 60, or 70 mph.
Global Variables	Benefit cost analysis assumptions and default values that are used throughout the workbook.	Discount rate (i), project life cycle (n), benefit days per year, select or define ADT 24-hour distribution curve, identify start and end of AM and PM peak periods, value of time and operating costs, population density (U or R).	Project specific peak and/or off-peak AVOs. Can provide ratio of benefits to new users (default assumes economic "rule of half")	Defaults should be used unless there is a compelling reason to do otherwise. Any modifications to the default values need to be documented.
24-Hour Volume Distribution Chart	Graphically displays the selected Year 1 directional and total volume distribution by hour of the day.	Select or define the ADT 24-hour distribution curve in the Global Variables worksheet. The selected curve will automatically be displayed in the 24 Hour Volume Distribution chart.	None	Graph only displays the selected Year 1 curve.
Estimate and B-C Ratio	Cost estimates for preliminary engineering, environmental retrofit, right-of-way, construction, operation & maintenance. Incorporates present value of user benefits for each particular improvement. Estimates the benefit / cost ratio.	Quantities needed for cost calculations, non-WSDOT cost share, and operation & maintenance costs, or total WSDOT present value costs (PVc).	User has the option of entering general cost per mile estimates, or a resultant total WSDOT present value cost (PVc) estimated outside of the worksheet.	Can use general cost per mile calculations or detailed cost calculations. Output from this worksheet are used as inputs to TOPSIS to prioritize highway mobility projects.

Worksheet	**Description**	**Required Inputs / Actions**	**Optional Inputs**	**Notes / Comments**
4 Step Model Benefits	Estimates annual 24-hour user benefits based on output from an accepted 4-step model.	Model description, truck %, peak period AVOs, and 24-hour vehicle-hours traveled on state facilities.	24-hour vehicle-hours traveled on entire system, not just state system.	Can estimate user benefits for entire system if data is provided, but only benefits for state system users will be incorporated into overall project B/C ratio.
Two Way Left Turn Lane (TWLTL) and Multilane Access Management Benefits	Estimates annual 24-hour user benefits for converting a 2-lane undivided facility to a 3-lane TWLTL facility (Harwood/St. John method), OR for median treatments and/or access spacing changes for 4-7 lane facilities (NCHRP 395 method).	Peak direction of selected ADT hourly distribution curve, median type, average access spacing, access control class, daily and peak hour traffic data, and truck %.	Peak and non-peak turns per access, if evaluating benefits using the NCHRP 395 method.	Uses ADT hourly distribution curve selected in Global Variables to estimate peak and off-peak percents and to convert working peak hour user benefits to 24-hour benefits.
General Purpose Lane Benefits	Estimates annual 24-hour user benefits for adding a general purpose lane. Facilities that can be analyzed include: a 2-lane highway, an arterial, a rural/small urban freeway, or a multilane highway or freeway.	No build and build posted speeds, direction(s) of added lane, ADT and K factor or working peak hour volumes, truck %, grade and length of grade, volume growth rate, and roadway type.	ADT and K factor or working peak hour volume is required, but either can be input. Can input data for one or two directions.	Benefits are estimated by each hour of the day for the selected direction(s) of the facility.
Climbing Lane Benefits	Estimates the annual 24-hour user benefits for adding a truck climbing lane to a 2-lane highway or to an arterial.	Same as above	Same as above	This worksheet has not been updated to look up values from the WSDOT speed-flow curve worksheet. WSDOT curves are embedded in worksheet.
Intersection Benefits	Estimates the annual 24-hour user benefits for improving an existing intersection.	No build and build total approach volumes, number of lanes, average intersection delays, and intersection v/c ratios, existing approach volumes by hour for 24 hours, and build scenario % reduction by approach.	Most recent counts of hourly approach volumes which can be converted to existing hourly approach volumes.	Benefits are estimated by each hour of the day. Since Year 20 VHT can be higher than Year 1 VHT, there is a potential for negative benefits. When negative benefits are estimated, they are assumed to be zero benefits.
New Interchange Benefits	Estimates the annual 24-hour user benefits for adding a new interchange to an existing facility.	Year 1 and Year 20 working peak hour volumes, distances and speeds or travel times for no build and build origin-destination paths.	Model travel times can be input for specific O-D paths instead of being calculated based on distances and speeds.	Working peak hour user benefits are converted to 24-hour benefits using ADT hourly distribution curve selected in Global Variables.

Worksheet	Description	Required Inputs / Actions	Optional Inputs	Notes / Comments
HOV Lane Benefits	Estimates the directional annual 24-hour user benefits for adding an HOV lane.	Directional number of lanes with and w/o project, ADT or directional working peak hour volumes, HOV and GP growth rates, truck %s, and traffic composition.	Can select the HCM 2000 speed-flow curve instead of using the WSDOT default curves. Can change default GP/HOV capacities per lane, but must document.	Benefits are estimated by each hour of the day for the selected direction(s) of the facility. Worksheet assumes that HOV lane can be used by GP traffic outside of the peak period.
Park & Ride Lot Benefits	Estimates the bi-directional annual 24-hour user benefits for constructing a park & ride lot.	Number of parking spaces, % of lot capacity used, various destination data, user distribution (transit riders/carpoolers), and AVOs.	None	24-hour benefits are assumed to be equal to working peak hour or peak period benefits.
Safety Benefits	Estimates the annual 24-hour user benefits of improving the safety of a facility.	Selection of safety improvements, identification of the number of accidents by type of accident.	None	None
SYNCHRO	Worksheet placeholder for icon link to SYNCHRO.	None	None	None
WSDOT Default Curves	Contains WSDOT default speed-flow curves for 50, 60, and 70 mph facilities. Speeds are dependent upon v/c ratio and the number of lanes. HOV lane speeds are dependent upon volumes.	None	None	The lowest allowed congested speed for general purpose lane speeds is 15.2 mph (for v/c >= 1.2). Allowable HOV lane speeds are 55 mph at free-flow down to 40 mph at capacity. HOV lane speeds are solely dependent upon lane volumes and an assumed capacit
HCM 2000 Curves	Contains the HCM 2000 speed-flow curves for freeways. Speeds are dependent upon free-flow speeds, length of segment, and v/c ratio.	Posted speed and length of section must be provided in the Project Description worksheet. These values are used to estimate speed-flow relationship.	None	Freeway speeds for GP and HOV lanes can range from free-flow speeds down to about 12 mph at a v/c of 2.0.

Project Description

Defining the Project

A project can consist of one or more improvement components that are designed to be implemented together. The MPPPbc software is designed and structured to work with several components of a proposed project, as long as specific assumptions are consistent among the project components. Benefits from the individual project components are analyzed separately in the individual benefit worksheets and then the resultant user benefits are summarized in the Estimate and B-C Ratio worksheet.

Requirements for Combining Project Components

Due to the structure of the MPPPbc software, in order for individual project components to be included in one workbook, they must have consistent assumptions. By definition, the global variable assumptions must be the same for the individual project components included in each workbook. These global variables include:

- discount rate (i);
- project life cycle (n);
- number of benefit days per year;
- 24-hour volume distribution;
- start and end times of AM and PM peak periods;
- population density (urban or rural);
- truck and auto average vehicle occupancies; and
- truck and auto values of time and operating costs.

Note that the following five benefit worksheets can be used in combination with any of the other benefit worksheets, as long as the global variable assumptions are consistent

- 4-step model;
- Intersection;
- New Interchange;
- Park and Ride Lot; and
- Safety.

Table 5 outlines the assumptions that must be consistent for each of the individual project components for them to be included in the same workbook.

Table 5. Project Component Assumption Requirements

Assumption	Worksheet(s)
Global Variables	All
No Build Posted Speed	Add General Purpose, Climbing, or HOV Lane
Length of Facility	Two Way Left Turn Lane, or Add General Purpose, Climbing, or HOV Lane
No Build and Build Number of Lanes	Add General Purpose, Climbing, or HOV Lane
Terrain	Add General Purpose, Climbing, or HOV Lane

Project Examples

The following examples are divided into projects that are recommended to be analyzed in a single workbook and those that are recommended to be handled in multiple workbooks.

Single Workbook

A single workbook is defined as the set of worksheets included in the original MPPPbc.xls workbook. While this workbook includes multiple worksheets, a single worksheet is provided for each of the types of benefit analyses (i.e., only one Park and Ride worksheet). If more than one type of improvement is included in the project (e.g., multiple Park and Ride lots), multiple workbooks should be used.

Examples where a single workbook can be used include:

- user has results of a 4-step model that was used to analyze *only* proposed project improvements, and safety benefits included in the 4-step model;
- two-way left turn and access management improvements, intersection improvements, and safety improvement;
- addition of general purpose lanes and a new interchange;
- addition of a general purpose lane in one direction and a climbing lane in the opposite direction; or
- addition of an HOV lane in two directions on same segment of freeway, a new park and ride lot, and safety benefits.

Multiple Workbooks

When benefits of individual project components must be analyzed in separate workbooks, the user can simply add the resultant individual benefits and/or costs to estimate an the overall project benefits and costs prior to input into TOPSIS.

Examples where multiple workbooks should be used include:

- adding a general purpose lane, climbing lane, and/or an HOV lane to multiple segments of a freeway;
- two way left turn and access management improvements along separate segments of a facility; or
- corridor improvements including two way left turn and access management improvements along certain segments in the corridor and freeway improvements along other segments in the corridor.

Analysis of Large Projects

It is important that the length of the facility being analyzed is large enough to include all of the benefits of the proposed project, and yet it should not be so large that the data used to evaluate the project is no longer representative of conditions throughout the analysis area. For example, if a 10 mile length of HOV lane is to be evaluated, it is tempting to specify 10 miles as the length of freeway to be analyzed. However, no single demand value or capacity value can be expected to be reliable for the entire length of the facility.

For those projects where either the demand or the capacity of the facility varies by more than 10% within the project boundaries, then the facility should be split into analysis sections. The demand and the capacity are both assumed to be unvarying within each analysis section. The benefits are estimated separately for each section and then accumulated for the entire length of the facility.

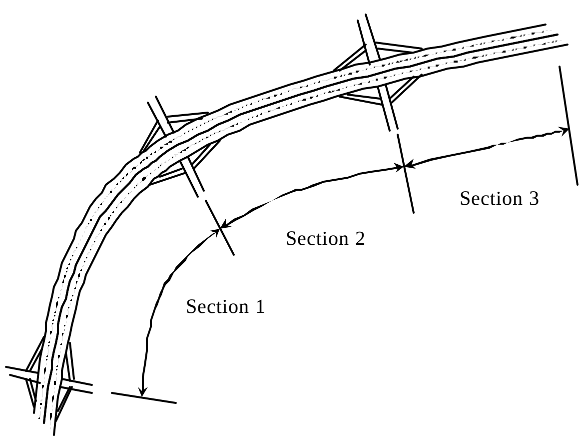


Figure 2. Segmenting of a Large Project

Analysis of Impacts Outside of Project Boundaries

Consideration of Upstream Impacts

While the queues in any one bottleneck section of the facility may physically extend beyond the boundaries of the facility under study, the benefit estimation procedures include all the delay associated with any vehicle attempting to traverse the facility during the analysis period. Thus it is not necessary to consider how far upstream the queues might extend under each alternative.

However the benefit analysis procedures do not currently track the secondary impacts of a queue blocking an upstream intersection or interchange and interfering with the traffic operations of other upstream facilities. Accurate analysis of these kinds of effects would require micro-simulation modeling, and this detailed analysis procedure is not recommended for planning and programming analyses.

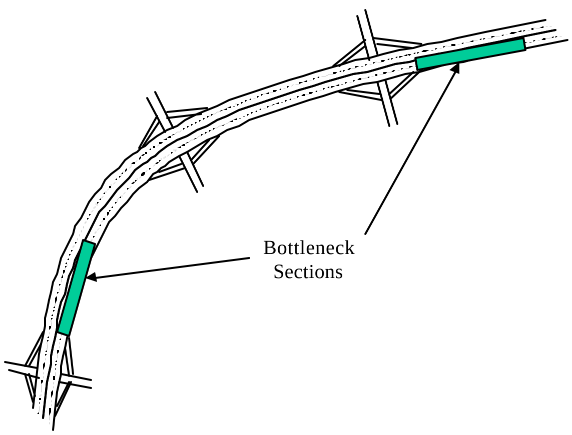


Figure 3. Segmenting of a Large Project

Analysis of Downstream Effects

A mobility improvement project that increases capacity can also be expected to cause more traffic per hour to impact a downstream bottleneck. This may cause additional delay to drivers passing through the downstream bottleneck, some of which did not benefit from the project improvements, because they did not pass through the project location.

Tracking of these kinds of impacts requires a network analysis model such as TP+, TRANPLAN, MINUTP, EMME/2, TMODEL, FREQ, TRANSYT7F, SYNCHRO and other software packages. These more elaborate analytical tools are appropriate at the alternatives analysis and project design stage, but are not feasible for planning and programming analyses. Where such analyses have been done prior to selection of a project for programming, it might be desirable to include their more accurate results in the prioritization process.

There is a risk that regions using the more elaborate analysis tools will show comparatively lower benefits for the same project than regions using more simplistic tools that do not capture the network impacts of capacity improvements. The "fairness" issue should be traded off against the greater accuracy in the benefits computations when using travel time savings computed using a network analysis model.

Project Description Data Input

The Project Description Worksheet is where the user inputs the project specific data that is used in most of the subsequent worksheets. The user should input the following information:

Analyst

Name, title, and/or other identifying information that allows reviewers to know who performed the benefit and cost calculations contained in the workbook.

Date

Date that the benefit and cost calculations were performed.

Project Title

The project title with enough information so that reviewers know what project components are included in the benefit and cost calculations.

State Route

The WSDOT state route(s) that is/are being analyzed in the workbook.

Posted Speed

The No Build posted speed on the state route(s) that is/are being analyzed in the workbook.

Note that the software currently only handles speeds of 50, 60, or 70 mph for freeways and speeds of 50 or 60 mph for arterials. If the user inputs a speed less than 50 mph, the software will default to the 50 mph speed-flow curves. If the user inputs a speed greater than 70 mph, the software will default to the 70 mph curves for freeways and 60 mph for arterials. Input speeds in between the allowable speeds will be rounded UP to the nearest allowable speed.

For the HOV lane analysis, the default free-flow speed in 55 mph.

Mileposts

The beginning and ending mileposts bounding the project improvement component. The length of the segment is calculated from these inputs.

> *If beginning and ending mileposts are NOT entered, the length of the segment will equal zero and subsequent worksheets will show errors of #DIV/0!*

Bi-directional Number of Lanes

The bi-directional number of *general purpose through* lanes for the no build and build conditions. The individual benefit worksheets allow the user to enter lanes by type and direction.

Terrain

Selection of level, rolling, or mountainous terrain. This selection only affects cost estimates.

Population Density

Selection of urban or rural population density. This selection affects the average vehicle occupancy (AVO) assumptions throughout the workbook.

Reports

The print area in the Project Description worksheet is set up to generate a single page report showing the project specific assumptions. This report is shown on the next page.

PROJECT DESCRIPTION WORKSHEET

Analyst:

Date:

Project Title:

State Route: **Posted Speed (50, 60 or 70 mph):**

Subject Section: **MP** **to** **MP**

Length of Subject Section: 0.00 **Miles**

Bi-directional Number of GP Lanes: **No - Build** **Build**

GP = General Purpose through lanes. Individual worksheets allow entry by lane type and direction.

Terrain for this project (*L* for Level, *R* for Rolling, *M* for Mountainous): R

Population Density (U for Urban, R for Rural): Rural

<----- Select population density. You selected Rural.

Global Variables

The global variables that are used throughout the MPPPbc.xls software are defined and stored in this worksheet.

Present Value Assumptions

Discount Rate (i)

As discussed in the Benefits Computation section of the Overview of WSDOT Benefit/Cost Methodology, the default standard discount rate for the constant dollar approach is 4%. If a policy decision is made in the future about changing the default discount rate, it should be changed in the Global Variables worksheet so that it is consistently applied.

Project Life Cycle (n)

As discussed in the Benefits Computation section of the Overview of WSDOT Benefit/Cost Methodology, the default project life cycle is 20 years. This value is used to determine the present value benefits and costs over the 20 life of the project. The user may change this default value in the Global Variables worksheet, but care should be exercised to ensure that the resultant benefit / cost estimates are appropriate.

Annual / Daily Benefit

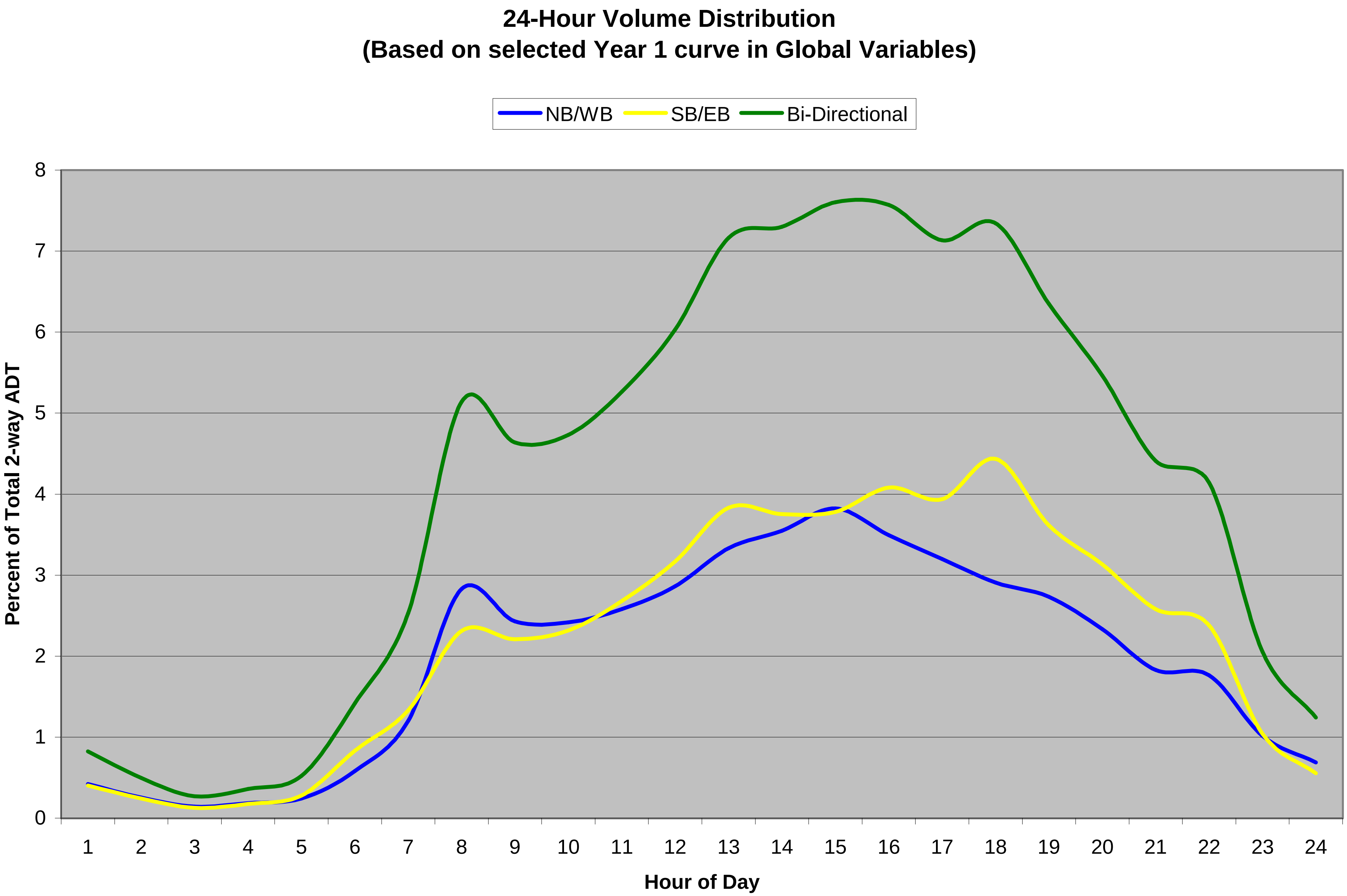
The default value for the ratio of annual benefits to daily benefits is 260 days per year. This value is used to convert 24-hour daily benefits to annual benefits.

24-hour Volume Distribution Curve

The selected or user input daily hourly volume distribution curve is used to convert hourly user benefits to 24-hour daily benefits. The hour with the highest bi-directional volume in the AM and the PM are considered the AM and PM peak hours, respectively.

The user must either select or define a 24-hour volume distribution curve Year 1 and Year 20. The pull down list identifies all of the distribution curves stored in Curve~Data.xls which is linked to MPPPbc.xls. The user could also define a 24-hour volume distribution curve separate from Curve-Data.xls by inputting ADT percentages by hour and direction into cells E72:F95 for Year 1 and E109:F132 for Year 20. A graphic display of the hourly volume distribution assumptions is shown in the 24-hour Volume Distribution chart immediately following the Global Variables worksheet (see Figure 5).

> *Remember, if you want to use the selected 24-hour volume distribution curve from Curve~Data.xls, make sure that all cells in the ranges E72:F95 and E109:F132 are "zeroed out".*


24-Hour Volume Distribution
(Based on selected Year 1 curve in Global Variables)
NB/WB
SB/EB
Bi-Directional
Percent of Total 2-way ADT
0
1
2
3
4
5
6
7
8
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour of Day

The user must select the AM and PM Peak Period START and END times. These times are used to identify the hours of the day in the peak period and to calculate the total peak period percent of the day. Peak and off-peak AVOs are applied in the GP Lane, Climbing Lane, Intersection Improvement, and HOV worksheets based on these select peak period start and end times.

Daily / Peak Hour Benefit Ratio

The TWTL and Interchange worksheets require an estimate of daily benefits to peak hour benefits. Since these worksheets use working peak hour volumes in their calculations, this value is used to convert peak hour user benefits to 24-hour daily benefits. The default estimate of this ratio is calculated by dividing the peak *period* volume percent by the peak *hour* volume percent. This value can be defined by the user.

Ratio of Benefits to New Users

The HOV Lane worksheet includes demand equations that account for new demand based on the presence of a HOV lane (affects HOV users during the peak period and all users during the off-peak period). In economic estimates, the benefits to "new" users are not usually valued the same as benefits to existing users. The benefit computations for "new" users are modified based on a given ratio of benefits to new users vs. benefits to existing users. The default value for this ratio employs the accepted economic "rule of half". Therefore, the estimated travel time savings for "new" users of the proposed HOV facility will be half of the estimated benefits to the existing users.

User Cost Parameters

As discussed in the Benefits Computation section of the Overview of WSDOT Benefit/Cost Methodology, the user cost parameters used in the user benefits estimation methodology include the value of traveler's time and vehicle operating costs. The value of a traveler's time depends on whether the trip is an auto or truck trip, average wage rates, and value of in-vehicle time as percentage of a wage rate. Vehicle operating costs depend on operating costs per mile and average running speeds. The default values for these variables result in hourly user benefit-cost parameters of $10 for autos and $50 for trucks.

Average Vehicle Occupancy Rates

The WSDOT prioritization process uses the concept of person trips rather than vehicle trips for estimation of both travel time savings and user operating cost savings. Therefore, to estimate user benefits, average vehicle occupancies (AVO) are used as multipliers in a combined procedure.

The Technical Advisory Committee determined AVO default values for the state of Washington after consulting data from the U.S. Census Bureau, the National Personal Transportation Survey, Puget Sound Regional Council travel surveys, and HOV monitoring studies. The AVO values, shown in Table 6 are broken down by region (urban vs. rural), vehicle, and lane type.

Table 6. Average Vehicle Occupancy Default Values

Region, Vehicle, and Lane Type	AVO
General purpose traffic within federally designated urbanized areas (populations > 200,000)	1.30
General purpose traffic – other	1.10
Truck traffic statewide (assumes one professional paid driver)	1.00
HOV lane / facility traffic	Requires site specific data

If these values are unacceptable, users can input project specific peak period and off-peak period AVOs. If any number is input in these cells, they will be used instead of the default values.

Reports

The print area in the Global Variables worksheet is set up to generate a one-page landscape report that shows the global variable assumptions. This report is shown on the next page.

DEFAULT GLOBAL VARIABLES WORKSHEET

Benefit/Cost Analysis Assumptions and Default Values

Present Value Assumptions

<----- Default values used throughout workbook. Must justify to WSDOT if you change.

Discount Rate (i):	***4%***	***annually***	
Project Life Cycle (n):	***20***	***years***	
Annual / Daily Benefit:	***260***	***days/yr***	
	Year 1	**Year 20**	
24-hour Volume Distribution Curve:	SR 4, MP 62.21	SR 4, MP 4.75	<----- Percent ADT hourly volume distribution curve to be used to convert peak-hour to 24-hour benefits. Can input project specific data by direction into cells $E$72-$F$95 and/or $E$109-$F$132.
AM Peak Period START Time:	7:00 AM	6:00 AM	<----- Enter AM peak period start time for Year 1 and Year 20.
AM Peak Period END Time:	8:00 AM	10:00 AM	<----- Enter AM peak period end time for Year 1 and Year 20.
PM Peak Period START Time:	4:00 PM	3:00 PM	<----- Enter PM peak period start time for Year 1 and Year 20.
PM Peak Period END Time:	5:00 PM	7:00 PM	<----- Enter PM peak period end time for Year 1 and Year 20. Note: Peak/Off-peak AVOs are used in GP, Climb, Int, and HOV worksheets based on start and end times.
AM Peak Period Percent:	***2.5%***	***13.7%***	
PM Peak Period Percent:	***7.6%***	***33.5%***	
Peak Period Percent of Day (AM+PM):	***10.1%***	***47.3%***	<----- Used in 4-Step Model, Two Way Left Turn Lane and Interchange worksheets.
Peak Hour Percent:	***7.6%***	***10.0%***	
Daily / Peak Hour Benefit Ratio:	***1.3***	***4.7***	<----- Peak period / Peak hour. Used in TWLTL and Interchange worksheets.
Ratio of Benefits to New Users:	***1/2***	***existing***	<----- Used in HOV worksheet. Based on economic "rule of half".

User Cost Parameters

	Autos	**Trucks**	
Value of Traveler's Time			
Average Wage Rate	$18.36	$20.22	<----- Source: WSDOT's Mobility Programming Criteria and Evaluation Procedures.
Value of In-Vehicle Time as % of Wage Rate	33%	100%	Truck values developed in consultation with the Teamsters Union.
Individual Value of Travel Time Per Hour:	***$6.12***	***$20.22***	
Vehicle Operating Costs			
Operating Costs per Mile	$0.07	$0.66	
Average running speed (mph)	50	50	
Vehicle Operating Costs Per Hour:	***$3.75***	***$32.85***	
Value of One Vehicle Hour (1 Driver)	**$9.87**	**$53.07**	
Hourly User Benefit-Cost Parameters:	***$10.00***	***$50.00***	<----- Default values used throughout workbook. Must justify to WSDOT if you change.

Average Vehicle Occupancy Rates

Population Density in Project Area	Urban		<----- Select population density. You selected Urban.
	Autos	**Trucks**	
Off-Peak Period AVOs - Default Values			
Urban Areas (population>200K)	1.21	1.0	
Rural Areas (remainder of State)	1.10	1.0	
Off-Peak Period AVOs - Project Specific			<----- Leave blank to use default values. If not default, must justify to WSDOT.
Off-Peak Period Values	***1.21***	***1.0***	<----- Off-peak AVO values based on user selected density. Used throughout workbook.
Peak Period AVOs - Default Values			
Urban Areas (population>200K)	1.30	1.0	
Rural Areas (remainder of State)	1.10	1.0	
Peak Period AVOs - Project Specific			<----- Leave blank to use default values. If not default, must justify to WSDOT.
Project Peak Period Values	***1.30***	***1.0***	<----- Peak AVO values based on user selected Urban density. Used throughout workbook.

Cost Estimate and Benefit / Cost Ratio

Introduction

The Estimate and B-C Ratio worksheet incorporates a proposed project's total costs and resultant user benefits, and estimates the benefit-cost data to be used in the TOPSIS prioritization software. On the cost side, it includes general cost estimates per mile, detailed project cost estimates, and residual values for all of the projects included in the workbook. On the benefits side, all net user benefits from each of the individual worksheets are incorporated in this spreadsheet.

Worksheet Organization and Inputs

The Cost Estimate and Benefit Cost Ratio worksheet is divided into 4 sections

- summary data
- general cost estimate
- detailed cost estimate
- cost summaries and benefit cost calculations

Data Inputs

In addition to the usual summary information that is copied into this worksheet from the "Project Description Sheet", the following information will be needed:

- Type of improvement
  - Arterial Lane
  - Climbing/Passing Lane
  - Freeway Lane
  - Intersection Improvements
  - Realignment
  - Shoulder Widening
- New or reconstructed bridges and IC's
- Detailed information such as:
  - Signals
  - Illumination
  - Wetland Mitigation
  - Right of Way

Worksheet Calculations

Cost Estimates

The worksheet automatically breaks the detailed cost estimate into the following categories for use in the TOPSIS algorithm.

- Preliminary Engineering
- Right of Way
- Structures
- Drainage/Grading
- Other

All relevant engineering costs as well as sales tax are automatically added to the project cost.

Residual Cost

Each category of the total project costs is weighted by different factors to calculate the residual cost for the project. The residual cost is intended to recognize that many portions of a project have a design life in excess of the standard 20 year planning horizon. The residual cost is the value used in all benefit/cost calculations.

Benefit/Cost Ratio

All project benefit worksheet values are automatically reported on this worksheet. All project benefit and cost values are converted to present value using the discount rate from the "Global Variables" input sheet.

Reports

The print area in the Estimate and B-C Ratio worksheet is set up to generate a two-page report showing the detailed cost assumptions, cost summaries, and benefit and cost calculations. This report is shown on the next two pages.

COST ESTIMATES, NPV, AND B/C RATIO WORKSHEET

Date: 04/19/2000
Analyst:

State Route: **Posted Speed (50, 60 or 70 mph):** 60
Project Title:
Subject Section: **MP** 0.00 **to** **MP** 0.00
Length of Subject Section: 0 **Miles**
Number of Lanes: **No - Build** 0 **Build** 0
Terrain for this project (*L* for Level, *R* for Rolling, *M* for Mountainous): L
Population Density (U for Urban, R for Rural) U

QUANTITY COST CALCULATIONS

General Cost per Mile Estimate:

	# of Lanes	Mile	Cost per lane mile	R/U*	Cost
Arterial Lane Addition			$1.6M to $3.5M	U	$0.0M to $0.0M
Add Climbing/Passing Lane			$1.3M to $7.0M	U	$0.0M to $0.0M
Freeway Lane Addition			$2.5M to $7.5M	U	$0.0M to $0.0M
Channelize Intersection			$0.15M to $0.60M	U	$0.00M to $0.00M
Realignment			$1.3M to $6.0M	U	$0.0M to $0.0M
Widen Shoulders			$0.5M to $3.0M	U	$0.00M to $0.00M
	Structure Width	Structure Length	Cost per SF		Cost
New Bridge			$100	U	$0
New Urban I/C			$425	U	$0
New Diamond I/C			$475	U	$0
GENERAL COST ESTIMATE			**$0**	**to**	**$0**

From Global Variables. **R = Rural, **U** = Urban*

Detailed Planning Cost Estimate:

		Quantity	Unit	Unit Cost	Other	Cost
STRUCTURES						
Bridge		0	SF	$100		$0
Walls	Retaining	0	SF	$25		$0
	Noise	0	LF	$260		$0
				STRUCTURES Subtotal		$0
DRAINAGE / GRADING						
Drainage	Ditch	0	LF	$5		$0
	Enclosed System	0	LF	$50		$0
Earthwork		0	LF	$125		$0
Clear/Grub	Shrubs/Grass	0.00	Acre	$1,000		$0
	Light Woods	0.00	Acre	$3,000		$0
	Heavy Forest	0.00	Acre	$5,000		$0
				DRAINAGE / GRADING Subtotal		$0
OTHER CONSTRUCTION						
Guardrail (# of Anchors in Other)		0	LF	$15		$0
Concrete Barrier		0	LF	$25		$0
Signals		0	EA	$250,000		$0
Illumination		0	EA	$8,000		$0
Signing/Striping		0	LF	$15		$0
Sidewalks, Curb, & Gutter		0	LF	$35		$0
Surface/Paving		0	LF	$100		$0
Roadside Development		0	IC	$100,000		$0
Wetland Mitigation		0.00	Acre	$100,000		$0
				OTHER CONSTRUCTION Subtotal		$0
Traffic Control (7% of Above Subtotals)				7%		$0
Removal Items (7% of Above .Subtotals)				7%		$0
				TOTAL CONSTRUCTION COSTS		$0
MOBILIZATION / CONTINGENCIES						
Mobilization (8% of Total Construction Costs)				8%		$0
Contingencies (5% of Total Construction Costs)				5%		$0
				MOBILIZATION / CONTINGENCIES Subtotal		$0
RIGHT-OF-WAY						
Right of Way		0	SF	$10	A	$0
OTHER ESTIMATED COSTS						
Preliminary Engineering (15% of All Above Costs)				15%		$0
Construction Engineering (20% of Total Construction Costs excl Wetland mitigation)				20%		$0
Sales Tax (7.6% of Total Construction Costs & Mobilization / Contingencies)				7.60%		$0
					TOTAL COST	**$0**

COST SUMMARIES

State Route:		**Posted Speed (50, 60 or 70 mph):**		60	
Project Title:					
Subject Section:	**MP**	0.00	**to**	**MP**	0.00
Length of Subject Section:		0	**Miles**		
Number of Lanes:	**No - Build**	0	**Build**	0	
Terrain for this project (L for Level, R for Rolling, M for Mountainous):				L	

			Residual Cost		
PRELIMINARY ENGINEERING	$0		1		$0
RIGHT OF WAY	$0		0.55		$0
CONSTRUCTION COST					
STRUCTURES	$0		0.57		$0
DRAINAGE / GRADING	$0		0.6		$0
OTHER	$0		1		$0
TOTAL PROJECT COST	**$0**				**$0**
PROJECT COST SHARE BY NON-WSDOT					$0
WSDOT RESIDUAL COST OF PROJECT					$0
ANNUAL OPERATION & MAINTENANCE	$0				$0
TOTAL PRESENT VALUE COST (PVc)				Calculated PVc:	$0
		OR		Input User Defined PVc:	

If WSDOT PVc have been estimated outside this worksheet, user can define PVc above. User defined cost will override worksheet PVc.

BENEFIT COST ESTIMATES - TOPSIS DATA

PRESENT VALUE OF BENEFITS

Lane Addition Benefits

Two Way Left Turn Lane	General Purpose Lane	Climbing Lane	Total GP Lanes
$0	$0	$0	$0

High Occupancy Vehicle Lanes, and Park & Ride Lots Benefits

HOV 2+ Lane	HOV 3+ Lane	Total HOV	Park & Ride Lot	Total Non-SOV
$0	$0	$0	$0	$0

Four-Step Model Estimates, and Safety Benefits

Four-Step Model	Safety	Total 4-Step, Safety	Total WSDOT User Benefits (PVb)
$0	$0	$0	$0

PRESENT VALUE OF COSTS

Project Cost Summaries

Total Project Cost	Residual Cost of Total (see above calcs)	Cost by NON-WSDOT	O & M Costs	Total	Total WSDOT Costs (PVc)
$0	$0	$0	$0	$0	$0

NET PRESENT VALUE AND BENEFIT / COST RATIO

Net Present Value	**Benefit / Cost Ratio**
$0	**No Costs**

4-Step Model Output Benefits

Introduction

The 4-Step Model Benefits worksheet is a new worksheet that has been provided to determine the travel time benefits of proposed projects based on results from a 4-Step Model.

Limitations

The 4-step Model Benefits worksheet is provided with the following caveats and warnings:

1. This is an optional worksheet for computing present value benefits for a project when regional model runs are available for both the with project and no project alternatives for both today's demands and 20 years in the future demands.

2. The regional model validation must have been reviewed and accepted by WSDOT.

3. The assumptions used in the project/no-project model runs (land use, road improvements etc.) must be documented for review by WSDOT.

4. Only benefits to the state highway system will be included in the project prioritization process. For state highway system benefits, vehicle hours traveled must be computed only for the state highway links in the model.

> *Both state highway and non-state highway data can be provided, but only benefits on the state highway system are incorporated into the overall benefit / cost estimate.*

Worksheet Organization and Inputs

The 4-Step Model worksheet is divided into five sections:

- summary data;
- traffic data;
- travel time savings;
- travel time savings distribution; and
- user benefits.

Data Inputs

In addition to the usual summary information that is copied into this worksheet from the "Estimate and B-C Ratio" worksheet, the following information will be needed:

- a description of the model from which output was obtained for use in this worksheet;
- truck percentages for Year 1 and Year 20;
- peak hour AVO for Year 1 and Year 20;
- Year 1 vehicle hours traveled, before and after the project; and
- Year 20 vehicle hours traveled, before and after the project.

Worksheet Calculations

Travel Time Savings

The worksheet computes the travel time savings from the difference in vehicle-hours traveled for build and no build alternatives for both today and Year 20 conditions.

Travel time savings are distributed to users based on truck percentages and peak and off-peak hour AVOs.

User Benefit

The resultant difference in travel time and/or travel hours is converted to present value benefits consistent with WSDOT benefits computations.

Reports

The print area in the 4-Step Model worksheet is set up to generate a one-page report that shows the traffic input data, the total travel time savings and travel time savings distribution, the user benefits calculation and the caveats associated with the 4-step model methodology. This report is shown on the next page.

4-STEP MODEL RESULTS WORKSHEET

Calculates user benefits associated with changes in daily vehicle hours traveled (VHT)

Date: 04/19/2000
Analyst:

Project Title:
Model Description:

Traffic Data

	Year 1	Year 20	
Truck %:	0.0%	0.0%	<----- Input truck percentages from accepted source(s).
Peak Hour AVO:			<----- Input peak hour AVO on state highways. Justify if different from WSDOT defaults.

Vehicle-Hours Traveled (24-Hour Period)	Year 1 No Build	Year 1 Build	Year 20 No Build	Year 20 Build	
State Highways	0	0	0	0	<----- Input applicable vehicle-hours on state highways from accepted model.
All Facilities	0	0	0	0	<----- Input applicable vehicle-hours on all facilities from accepted model.
State Highway %	0%	0%	0%	0%	

Travel Time Savings (24-Hour)

<----- Travel time savings = travel time without project - travel time with project.

	Year 1			Year 20	
State Highways	0.00	veh-hours	State Highways	0.00	veh-hours
All Facilities	0.00	veh-hours	All Facilities	0.00	veh-hours

Travel Time Savings Distribution (24-Hour)

<----- Distributes to users based on truck %.

	Year 1			Year 20	
State Hwy - GP	0.00	veh-hours	State Hwy - GP	0.00	veh-hours
State Hwy - Truck	0.00	veh-hours	State Hwy - Truck	0.00	veh-hours
All Facilities - GP	0.00	veh-hours	All Facilities - GP	0.00	veh-hours
All Facilities - Truck	0.00	veh-hours	All Facilities - Truck	0.00	veh-hours

Daily User Benefits Calculation

<----- Estimates daily user benefits based on peak hour percent of day for Year 1 & Year 20.

Year 1 peak period percent = 10.1% (from Global Variables)
Year 20 peak period percent = 47.3% (from Global Variables)

	Year 1		Year 20
State Highways	**$0**	State Highways	**$0**
All Facilities	**$0**	All Facilities	**$0**

Present Value of User Benefits Calculation

Present Value Factor (PVF)

State Highways	**PVF = 0.00**	All Facilities	**PVF = 0.00**

Total Present Value of User Benefits

State Highways	**$0**	All Facilities	**$0**

1. This is an optional worksheet for computing present value benefits for a project when regional model runs are available for both the with project and no project alternatives for both today's demands and 20 years in the future demands.

2. The regional model validation must have been reviewed and accepted by WSDOT.

3. The assumptions used in the project/no-project model runs (land use, road improvements etc.) must be documented for review by WSDOT.

4. Only benefits to the state highway system will be included in the project prioritization process. For state highway system benefits, person hours traveled must be computed only for the state highway links in the model.

Two-Way Left Turn Lane/ Access Management Benefits

Introduction

The two-way left-turn lane (TWLTL) worksheet is used to determine the travel time benefits of these kinds of projects:

- adding a TWLTL to a two-lane roadway;
- changing the type of median on a four- to seven-lane roadway; and/or
- changing the access spacing provided on a four- to seven-lane roadway.

If a project involves both the addition of through lanes and changes in median type or access spacing, two worksheets should be used. The "general purpose lanes benefits" worksheet should be used first to calculate the travel time savings resulting from the increased capacity provided by the added lane, and the TWLTL spreadsheet should be used second to determine the travel time savings resulting from the median and access spacing changes, with the added lane in place.

Limitations

The worksheet is based on two different analysis techniques, one for two-lane roadways and one for multi-lane roadways. The two-lane methodology ("Harwood/St. John") does not provide as many options as the multi-lane methodology ("NCHRP 395"). Specifically, the following kinds of situations cannot be analyzed with this worksheet:

- access spacing changes on two-lane roadways;
- adding a raised median, or converting a TWLTL to another median type, on two-lane roadways; or
- converting a four-lane undivided roadway to a three-lane roadway with a TWLTL.

Assumptions

Users should note that while the worksheet allows asymmetrical roadways to be analyzed (more through lanes in one direction than the other), the methodologies on which the worksheet is based were developed from data collected on symmetrical roadways. Also, the methodologies assume an equal number of access points on both sides of the street.

Worksheet Organization and Inputs

The TWLTL worksheet is divided into six sections:

- summary information;
- facility data;
- daily traffic data;
- peak hour traffic data;
- peak hour delay calculation; and
- user benefit.

Data Inputs

In addition to the usual summary information that is copied into this worksheet from the "Estimate and B-C Ratio" worksheet, the following information will be needed:

- number of through lanes in the peak and non-peak directions, before and after the project;
- the median type before and after the project;
- the average access spacing before and after the project;
- the roadway's access control class before and after the project;
- Year 1 and Year 20 ADTs;
- the average through, right-turn, and left-turn volume per access point in both directions during the peak hour, with and without the project, in Year 1 and Year 20; and
- the proportions of autos and trucks using the roadway during the peak hour.

If one or more of these inputs changes over the length of the project, each section that has similar characteristics should be analyzed separately. The user benefits from each section should then be summed by hand to determine the total project benefits.

Worksheet Use

Summary Data

The summary data section, located at the top of the spreadsheet, contains general project information. All of the items in this section are copied from the "Estimate and B-C Ratio" worksheet and cannot be changed here.

Facility Data

Enter information about the facility's physical characteristics in this section. The required information is listed below.

Peak Direction Through Lanes. Enter the number of lanes for through traffic provided in the peak direction, from 1 to 3. If the no-build number of lanes is 1, the build number of lanes must also be 1, because different methodologies are used for calculating delay on two-lane and multi-lane highways. An error message will be displayed if the lane choices are incompatible.

Non-Peak Direction Through Lanes. Enter the number of lanes for through traffic provided in the non-peak direction, from 1 to 3.

Median Type. The drop-down lists provide three options: Undivided, TWLTL, and Raised Median. If the number of through lanes is 1, the no-build setting must be undivided and the build setting must be TWLTL. An error message will be displayed if the selections for median type are incompatible.

Average Access Spacing. Enter the number of feet between access points (centerline to centerline) on the roadway, for both no-build and build conditions. The procedures assume that the spacing is the same on both sides of the roadway. If the number of through lanes is 1, only the build spacing will be used in the calculation. If the no-build and build spacings are different, but the turning volumes per access remain the same (entered in the "Peak Hour Traffic Data" section), a warning message will appear noting that turning volumes do not appear to have been redistributed between the remaining accesses.

Access Control Class. The drop-down lists provide three options for the access control class: Class I, II, or III. These selections are used in the next section of the worksheet to make sure that a TWLTL, if proposed, will conform to WSDOT's access control policy.

Daily Traffic Data

This section double-checks that a TWLTL (if proposed as part of the project) will conform to WSDOT's access control policy. Enter the facility's ADT for the no-build and build conditions. The worksheet will compare the volumes and proposed median type to the facility's access control class. If the Volume Check for TWLTL cells says "OK," the proposed median treatment is consistent with WSDOT policy. If not, the cells will say "TWLTL not allowed."

Peak Hour Traffic Data

Enter traffic volume information in this section. You'll be entering the same kind of information four or eight times, once for each combination of peak vs. non-peak direction, Year 1 vs. Year 20, and no-build vs. build. If you're analyzing a two-lane roadway with a TWLTL, you'll only need to enter data in the unshaded cells (build condition). If you're analyzing a multi-lane roadway, enter information in both the shaded and unshaded cells (no-build and build conditions).

Turning movement volumes at each access point will be different. However, you only need to enter peak hour through, left-turn, and right-turn volumes for an "average" access point for each direction.

Worksheet Calculations

Peak Hour Delay Calculation

This worksheet section calculates the travel time benefits (or disbenefits) of the proposed project. Each of the lines in this section is explained below.

Computation Method. If a two- or three-lane roadway is being analyzed, this will read "Harwood/St. John." If a four-or-more-lane roadway is being analyzed, this will read "NCHRP 395."

Peak Direction Through Delay. This is the delay experienced by through vehicles due to left-turning vehicles stopping or slowing in the through lane. The delay is expressed in vehicle-hours.

Non-Peak Direction Through Delay. The same as above, but in the opposite direction.

Peak Direction Left Turn Delay. This is the delay, in vehicle-hours, experienced by left-turning vehicles, as a result of having to yield to traffic in the opposite direction before making a turn.

Non-Peak Direction Through Delay. The same as before, in the opposite direction.

Peak Hour Travel Time Savings. These are the differences between the sums of the through and left-turn delays for each direction as a result of the project, in Year 1 and Year 20. The results are given in vehicle-hours.

> *No calculation results will appear in the "no-build" columns if the "Harwood/St. John" method (two-lane roadways) is being used, as the method calculates the build condition travel time savings directly.*

User Benefit

The last worksheet section calculates the value of the travel time savings as discussed in the Benefits Computation section of this document. You'll need to specify the peak hour proportion of automobiles and trucks, which must total 100%. The two modes have different values of time and different average vehicle occupancies, which are used to convert the vehicle-hours of delay used in the previous section to person-hours.

> *If "ERROR" appears in the lower right corner of the worksheet, one or more of your entries needs to be revised. Scroll back up the worksheet and look for error messages in the right column that will indicate the cause of the problem.*

Reports

The print area in the TWLTL worksheet is set up to generate a one-page report that shows the facility and traffic input data, the peak hour delay calculation, including computation method, and the user benefits calculation. This report is shown on the next page.

TWO WAY LEFT TURN LANE WORKSHEET

Capacity Improvement (TWLTL and/or access management)

			Date:	04/19/2000	
SR:			Analyst:		
Project Title:				Year 1	Year 20
Subject Section:	0.00	to MP 0.00	ADT % Curve:	SR 4, MP 62.21	SR 4, MP 4.75
Length of Subject Section:	0.00	miles	Peak Percent:	10.1%	47.3%
			Non-Peak Percent:	89.9%	52.7%
Daily/Peak Benefit Ratio:	1.3	hours/day	(Based on ADT% curve, peak direction and hours per peak period.)		
Annual/Daily Benefit Ratio:	260	days/year			

Facility Data

	No-Build		Build	
Peak Direction Through Lanes:		lanes		lanes
Non-Peak Direction Through Lanes:		lanes		lanes
Median Type:	Undivided		TWLTL	
Average Access Spacing:		feet		feet
Access Control Class:	Class III		Class III	

Daily Traffic Data

	Year 1		Year 20	
ADT:		veh/day		veh/day
Volume Check for TWLTL:	OK		OK	

Peak Hour Traffic Data

	No-Build		Build		
	Year 1	Year 20	Year 1	Year 20	
Peak Direction					
Average Through Volume:	0	0	0	0	veh/h/acc
Average Right Turns per Access:	0	0	0	0	veh/h/acc
Average Left Turns per Access:	0	0	0	0	veh/h/acc
Non-Peak Direction					
Average Through Volume:	0	0	0	0	veh/h/acc
Average Right Turns per Access:	0	0	0	0	veh/h/acc
Average Left Turns per Access:	0	0	0	0	veh/h/acc

Peak Hour Delay Calculation

	No-Build		Build		
	Year 1	Year 20	Year 1	Year 20	
Computation Method:			Harwood/St. John	Harwood/St. John	
Peak Direction Through Delay:					veh-h
Non-Peak Direction Through Delay:					veh-h
Peak Direction Left Turn Delay:					veh-h
Non-Peak Direction Left Turn Delay:					veh-h
Peak Hour Travel Time Savings (TTS):			0.000	0.000	veh-h

User Benefit

	Autos	Trucks		Total	
Percent of Users:				ERROR: Must total 100%	
Value of Time:	$10.00	$50.00			$/h
Peak Hour AVO:	1.3	1			persons
Daily Travel Time Savings, Year 1:	0.000	0.000		0.000	person-h
Daily Travel Time Savings, Year 20:	0.000	0.000		0.000	person-h
User Benefit, Year 1:	$0	$0		$0	
User Benefit, Year 20:	$0	$0		$0	
Year 20 / Year 1 User Benefits				0.00	
Annual Growth Rate, r	= [ln(Year 20 Benefits/Year 1 Benefits) / # of Years]			0.00	
Analysis Period, n				20	
Discount Rate, i				4.0%	
Present Value Function (PVF)	= [(exp((r-i)n)-1)/(r-i)]			13.77	

Present Value of User Benefits: $0

ERROR

Add General Purpose or Climbing Lane Benefits

Introduction

The General Purpose Lane worksheet is used to determine the travel time benefits of adding a general purpose lane to:

- a urban multilane highway or freeway,
- a rural or small urban freeway,
- a two-lane highway, or
- an arterial;

The Climbing Lane worksheet is used to determine the travel time benefits of adding a climbing lane to:

- a two-lane highway.

Limitations

The entire workbook is set up to analyze facilities with posted speeds of 50, 60 or 70 mph. These speeds are appropriate for freeways and highways, but many arterials operate at speeds less than 50 mph. Therefore, the MPPPbc software is limited to analyzing the user benefits of adding general purpose lanes to:

- freeways;
- highways; or
- arterials with capacity and speed assumptions applicable to state highways in urban areas with no or few signals.

Worksheet Organization and Inputs

The General Purpose Lane and Climbing Lane worksheets are divided into five sections:

- summary information;
- traffic data;
- traffic volume distribution;
- capacity data; and
- user benefit.

Data Inputs

In addition to the usual summary information that is copied into this worksheet from the "Estimate and B-C Ratio" worksheet, the following information will be needed:

- posted speed, before and after the project;
- number of lanes by direction, before and after the project;
- Year 1 Volumes (AWDT or VHD and factors);
- the proportions of autos and trucks using the roadway during the peak hour:
- grade and length of grade;
- capacity assumptions; and
- roadway type, before and after the project.

> *If one or more of these inputs changes over the length of the project, each section that has similar characteristics should be analyzed separately. The user benefits from each section should then be summed by hand to determine the total project benefits.*

Worksheet Use

Summary Data

The summary data section, located at the top of the spreadsheet, contains general project information. Most of the items in this section are copied from the "Estimate and B-C Ratio" worksheet and cannot be changed here.

The user must input the following data in this section:

Posted Speed Limit. The user must input the posted speed limit under build conditions. The No build posted speed limit is copied from the Estimate and B-C Ratio worksheet.

Directional Number of Lanes. The user must input the number of lanes before and after the project.

Traffic Data

ADT or Peak Hour Volume and K Factor. The user must input the ADT volume OR a peak hour volume AND an associated K factor which can be used to estimate an ADT.

Truck Percentage. The user should input the percent of total users who are truck operators.

Capacity Data

Enter information about the facility's physical characteristics in this section. The required information is listed below.

Capacity per Lane. The user has the option of changing the assumed capacity per lane by facility type.

Section Type. The user must input anything (e.g. "X") to indicate the facility type before and after the project.

Worksheet Calculations

Maximum Hourly Capacity

A maximum hourly capacity for the segment under build and no build conditions is estimated based on the percent trucks, percent grade, length of grade, and number of lanes.

Hourly Demands

The Year 1 hourly demands are forecasted using 24-hour distribution curves based on actual traffic counts for the subject section of roadway or from other similar roadways if counts are not available. Year 20 hourly volumes are estimated using the user input growth rate and a straight-line extrapolation.

Peak Hour Spreading

If hourly demands exceed the 1.2 times the capacity of the facility, excess volumes are redistributed as discussed in the Capacity Constraint and Peak Spreading section of this report (see Page 1).

Volume-to-Capacity Ratios

Year 1 and Year 20 no build and build volume-to-capacity ratios are calculated by dividing the resultant hourly demands by the appropriate facility capacity. Since peak hour spreading was cursorily handled above, no v/c ratio will be greater than 1.2 times the capacity.

Mean Operating Speeds

Mean operating speeds are determined for each hour based on look-up tables and the computed volume/capacity ratio for the build and no-build conditions for Year 1 and Year 20.

Travel Time Savings

Hourly travel times are estimated by dividing the length of the facility by the mean operating speed and multiplying by the volume. The vehicle-hours of travel (VHT) for the mixed flow (general purpose) lanes are split between trucks and non-trucks.

User Benefits

The cumulative user benefits for Year 1 and Year 20 are computed using the travel time savings and cost parameters. The resultant present value benefits are estimated using the discount rate contained in the worksheet and a present value factor as discussed in the Benefits Computation section of this document. This value is then transferred into Estimate and B-C Ratio worksheet.

Reports

The print area in the General Purpose and the Climbing Lane worksheets are set up to generate two-page reports. The first page lists the input data and shows the computed adjusted facility capacities. The second page shows the hourly user benefits computation by direction and the resultant total present value of the benefits. A sample of the report for the addition of general purpose lanes is shown on the next two pages.

ADD GENERAL PURPOSE LANE WORKSHEET

Capacity Improvement (additional general purpose lanes)

Date: 04/19/2000

Analyst:

		No - Build	Build
State Route:	**Posted Speed**	60	60

Project Title:

Subject Section:	**MP**	0	**to MP**	0
Length of Subject Section:		0	**Miles**	
		No - Build	**Add GP**	**Build**
	Bi-directional # of Lanes:	0	0	0
	NB/WB:			0
	SB/EB:			0
Speed-Flow Curves:		WSDOT Default	HCM 2000 curves only valid for freeway analyses !!!	

Traffic Data

	Year 1		Year 20
ADT		vpd in both directions	**0**
Peak Hour Volume		vph in both directions	
K factor		MUST input K factor OR ADT	
Truck %	0%		**0%**
Grade	0	e.g., 0.03	
Length of grade	0	miles	
Growth Rate	0.0%		

Traffic Volume Distribution Curve

ADT Hourly % Curves	Year 1:	SR 4, MP 62.21	Selected in Global Variables
	Year 20:	SR 4, MP 4.75	Selected in Global Variables
Peak Period AVO		1.3	Defined in Global Variables

Capacity

Roadway Type	**Defaults**	**Base**		**Section Type No Build**	**Section Type Build**
Urban Multilane Highway or Freeway	2,200	2,200	vphpl		
Rural/Small Urban Freeway	2,000	2,000	vphpl		
2 Lane Highway	1,300	1,300	vphpl		
Arterial	1,600	1,600	vphpl		

Put 'X' in cells to select section type

	NB/WB	SB/EB
Capacity under No Build conditions:	*0*	*0*
Capacity under Build conditions:	*0*	*0*

Note: Capacities are directional and have been adjusted for trucks and grades.

User Benefits			
Hour	**NB or WB**	**SB or EB**	**Total**
1	$0	$0	$0
2	$0	$0	$0
3	$0	$0	$0
4	$0	$0	$0
5	$0	$0	$0
6	$0	$0	$0
7	$0	$0	$0
8	$0	$0	$0
9	$0	$0	$0
10	$0	$0	$0
11	$0	$0	$0
12	$0	$0	$0
13	$0	$0	$0
14	$0	$0	$0
15	$0	$0	$0
16	$0	$0	$0
17	$0	$0	$0
18	$0	$0	$0
19	$0	$0	$0
20	$0	$0	$0
21	$0	$0	$0
22	$0	$0	$0
23	$0	$0	$0
24	$0	$0	$0

Total Present Value of User Benefits
$0

Intersection Improvement Benefits

Introduction

This worksheet estimates the user benefits associated with improving an existing signalized intersection. The analysis is based on a methodology developed by Karl Westby for his thesis at the University of Washington.

Worksheet Organization and Inputs

The Intersection Improvements worksheet is divided into five sections:

- overall intersection information;
- existing traffic volume data by approach and hour of day;
- no build and build traffic volume estimates for Year 1 and Year 20;
- overall intersection delay estimates by hour; and
- user benefit.

Data Inputs

This worksheet requires 24-hour traffic counts for each approach to the study intersection, and base year no build and base year build calculated intersection average peak hour delays.

The worksheet allows the following input data from the user.

- truck percentage;
- volume growth rate;
- Year 1 peak hour total approach volume, before and after the project;
- Year 1 total number of lanes, before and after the project;
- Year 1 peak hour average delay, before and after the project;
- Year 1 peak hour intersection v/c ratio, before and after the project; and
- build scenario volume reduction by approach.

Worksheet Calculations

Maximum Hourly Capacity

Maximum hourly capacities for the intersection under build and no build conditions are estimated based on the input total approach volume and the overall intersection v/c ratio by the following formula:

$$C = (TV) / (V/C_{INT})$$

where:

C = total intersection capacity

TV = total intersection peak hour approach volume, as input by user

V/C_{INT} = overall intersection peak period volume-to-capacity ratio, as input by user

Hourly Demands

Year 1 and Year 20 no build hourly demand volumes are estimated by approach from the existing volumes, the user provided growth rate, and assuming a straight-line extrapolation.

The hourly demand volumes for the build scenario are estimated by reducing the no build volumes by the user provided percent reduction by approach. If all percent reductions by approach are zero, the build and no build demand volumes will be equal. If hourly demands exceed the calculated capacity of the intersection as determined above, excess volumes are redistributed to the previous hour. The resultant total approach volumes for any over-capacity hour will equal the calculated capacity of the intersection, and that hour will be marked as over-capacity.

Since the estimation of intersection delay is dependent upon the maximum of Approach 1+2 or Approach 3+4, the hourly maximum sum volumes (MSV) are redistributed by hour by the same percent that the total approach volumes are adjusted.

V/C Ratio

An "uncorrected" v/c ratio is calculated using the equation shown below.

$$V/CU = 0.00185 * (TVADJ / L) – 0.542 * (MSVADJ / TVADJ) + 0.918 * (V/CINT) – 0.00147 * (TV / L)$$

where:

V/C_U = uncorrected hourly volume-to-capacity ratio

TV_{ADJ} = adjusted hourly total approach volume

L = total number of lanes on all approaches

MSV_{ADJ} = adjusted hourly maximum sum of approach volumes (approach 1+2 or approach 3+4)

V/C_{INT} = overall intersection peak period volume-to-capacity ratio, as input by user

TV = total intersection peak hour approach volume, as input by user

Overcapacity Conditions

If the calculated v/c ratio for any over-capacity hour is less than 1.0, the v/c ratio for that hour is "corrected" and reset to 1.0. Then, the hourly intersection delay is estimated by the following equation developed by Karl Westby.

$$DH = EXP(7.11 + 4.25 * V/CC + 0.000494 * TVADJ[4] - 1..319 * (MSVADJ / TVADJ) + 0.000000643 * (DINT / TV)) / 3600$$

where:

D_H = hourly delay in hours

V/C_C = the "corrected" hourly volume-to-capacity ratio

TV_{ADJ} = adjusted hourly total approach volume (= intersection capacity for over-capacity conditions)

MSV_{ADJ} = adjusted hourly maximum sum of approach volumes (approach 1+2 or approach 3+4)

TV = total intersection peak hour approach volume, as input by user

D_{INT} = total intersection peak hour delay in hours, as input by user

Travel Time Savings

The savings in travel times are estimated based on the difference in delay between the build and no build scenarios.

User Benefits

The user benefits for Year 1 and Year 20 are computed using these travel times savings and user input cost parameters for autos and trucks. The resultant present value of benefits is estimated using the discount rate contained in the worksheet and a present value factor as discussed in the Benefits Computation section of this document. This value is then transferred into Estimate and B-C Ratio worksheet.

> *Since Year 20 VHT can be higher than Year 1 VHT, there is a potential for negative benefits. When negative benefits are estimated for a particular hour, there are assumed to be zero benefits for that hour.*

Since this method estimates user benefits based on the change in intersection delay, and the delay equation has a parameter that is positively related to the estimated total demand of the intersection, the user benefits for certain hours of the day can actually be negative. This occurs during the hours when an intersection is estimated to be at or above capacity under both the no build and build scenarios. In this situation, the delay equation estimates the hourly delay under the build scenario to be significantly greater than the delay under the no build scenario. This discrepancy is likely due to the fact that the delay equation has a parameter that is sensitive to the total intersection demand, and this parameter is not tempered by an adjustment for an increase in capacity due to the project (see Footnote 4).

Reports

The print area in the Intersection worksheet is set up to generate a five-page report that shows the input data, the approach volumes under existing, Year 1 no build and build, and Year 20 no build and build scenarios, the user benefits computation by hour, and the resultant total present value of benefits. This report is shown on the next five pages.

[4] This parameter is sensitive to the total intersection demand and is capped at the estimated build and no build intersection capacities. Therefore, when the project increases the intersection capacity and the intersection operates at capacity, this parameter is greater under build conditions than under no build conditions. Since this parameter is not tempered for the increase in capacity due to project improvements (e.g. adjusted based on the change in number of lanes), the total estimated delay is increased with increased capacity.

INTERSECTION IMPROVEMENT WORKSHEET

Capacity Improvement (reduced average delay)

State Route: ____________ **Date:** 04/19/2000

Mileposts: ____________ **Analyst:** ____________________

Project Title: ____

Truck %: 0.0%

Volume Growth Rate: 0.0%

Year 1 No-Build

Total Approach Volume		vph
Number of Lanes		
Average Delay		seconds
Year 1 No Build Intersection V/C		

Year 1 Build

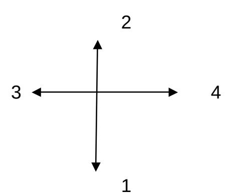
Total Approach Volume		vph
Number of Lanes		
Average Delay		seconds
Year 1 Build Intersection V/C		

Build Scenario % Reduction By Approach

Approach 1	0.0%
Approach 2	0.0%
Approach 3	0.0%
Approach 4	0.0%

Cost Information

Peak Period AVO	1.3
Truck Occupancy	1.0
Cost Parameter - Auto	$10.00
Cost Parameter - Truck	$50.00



NOTE:
INPUT VOLUMES IN THE APPROPRIATE COLUMN UNDER THE DIRECTIONAL ARROWS

Existing Vol

Hour	Approach 1	Approach 2	Approach 3	Approach 4
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0
1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0
	0	0	0	0

Year 1 No Build

Hour	**Approach 1**	**Approach 2**	**Approach 3**	**Approach 4**
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0
1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0
	0	0	0	0

Year 1 Build

Hour	**Approach 1**	**Approach 2**	**Approach 3**	**Approach 4**
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0
1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0
	0	0	0	0

Year 20 No-Build Volumes

Hour	Approach 1	Approach 2	Approach 3	Approach 4
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0
1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0
	0	0	0	0

Year 20 Build Volumes

Hour	Approach 1	Approach 2	Approach 3	Approach 4
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0
1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0
	0	0	0	0

Intersection Total Delay in Hours

Hour	Yr 1 No Build		Year 1 Build		Yr 20 No Build		Year 20 Build
0100	0.0		0.0		0.0		0.0
0200	0.0		0.0		0.0		0.0
0300	0.0		0.0		0.0		0.0
0400	0.0		0.0		0.0		0.0
0500	0.0		0.0		0.0		0.0
0600	0.0		0.0		0.0		0.0
0700	0.0		0.0		0.0		0.0
0800	0.0		0.0		0.0		0.0
0900	0.0		0.0		0.0		0.0
1000	0.0		0.0		0.0		0.0
1100	0.0		0.0		0.0		0.0
1200	0.0		0.0		0.0		0.0
1300	0.0		0.0		0.0		0.0
1400	0.0		0.0		0.0		0.0
1500	0.0		0.0		0.0		0.0
1600	0.0		0.0		0.0		0.0
1700	0.0		0.0		0.0		0.0
1800	0.0		0.0		0.0		0.0
1900	0.0		0.0		0.0		0.0
2000	0.0		0.0		0.0		0.0
2100	0.0		0.0		0.0		0.0
2200	0.0		0.0		0.0		0.0
2300	0.0		0.0		0.0		0.0
2400	0.0		0.0		0.0		0.0
Daily	0.00		0.00		0.00		0.00

	Year 1	Year 20
Total Travel Time Savings:	0.00	0.00

	User Benefits			
	Year 1	Year 20	PVF	Present Value
0100	$0	$0	0.00	$0
0200	$0	$0	0.00	$0
0300	$0	$0	0.00	$0
0400	$0	$0	0.00	$0
0500	$0	$0	0.00	$0
0600	$0	$0	0.00	$0
0700	$0	$0	0.00	$0
0800	$0	$0	0.00	$0
0900	$0	$0	0.00	$0
1000	$0	$0	0.00	$0
1100	$0	$0	0.00	$0
1200	$0	$0	0.00	$0
1300	$0	$0	0.00	$0
1400	$0	$0	0.00	$0
1500	$0	$0	0.00	$0
1600	$0	$0	0.00	$0
1700	$0	$0	0.00	$0
1800	$0	$0	0.00	$0
1900	$0	$0	0.00	$0
2000	$0	$0	0.00	$0
2100	$0	$0	0.00	$0
2200	$0	$0	0.00	$0
2300	$0	$0	0.00	$0
2400	$0	$0	0.00	$0
SUM	**$0**	**$0**		

Present Value of User Benefits

$0

0 Hours at capacity for year 1 no build
0 Hours at capacity for year 1 build
0 Hours at capacity for year 20 no build
0 Hours at capacity for year 20 build

New Interchange Benefits

Introduction

This worksheet estimates the user benefits associated with adding a new interchange at a new access point.

Worksheet Organization and Inputs

The Interchange worksheet is divided into four sections:

- traffic data;
- origin and destination data;
- travel time savings calculations; and
- user benefits.

Data Inputs

The main difference in this worksheet from the others is that it requires input from a transportation model that can provide changes in travel time due to new access point.

The worksheet allows the following input data from the user.

- Percent of Trucks
- Year 1 and Year 20 On- and Off-ramp Volumes
- Mainline K-Factor
- Segment Speeds and Distances, or Travel Times

Worksheet Calculations

O-D Travel Times

The travel times are estimated for individual segments of designated origin/destination paths for Year 1 and Year 20 build and no build conditions. Travel times are based on segment lengths and speeds, or from model input. The individual segments are added together to estimate the total origin/destination travel time under build and no build conditions.

Travel Time Savings

The travel times savings for Year 1 and Year 20 are computed separately by subtracting the travel time under build conditions from the travel time under no build conditions.

User Benefits

The cumulative user benefits for Year 1 and Year 20 are computed using the travel time savings and cost parameters. The resultant present value benefits are estimated using the discount rate contained in the worksheet and a present value factor as discussed in the Benefits Computation section of this document. This value is then transferred into Estimate and B-C Ratio worksheet.

Reports

The print area in the Interchange worksheet is set up to generate a six-page report that shows the input data, the individual origin/destination travel speeds, lengths and times, and the user benefits computation the resultant total present value of the benefits. This report is shown on the next six pages.

NEW INTERCHANGE WORKSHEET

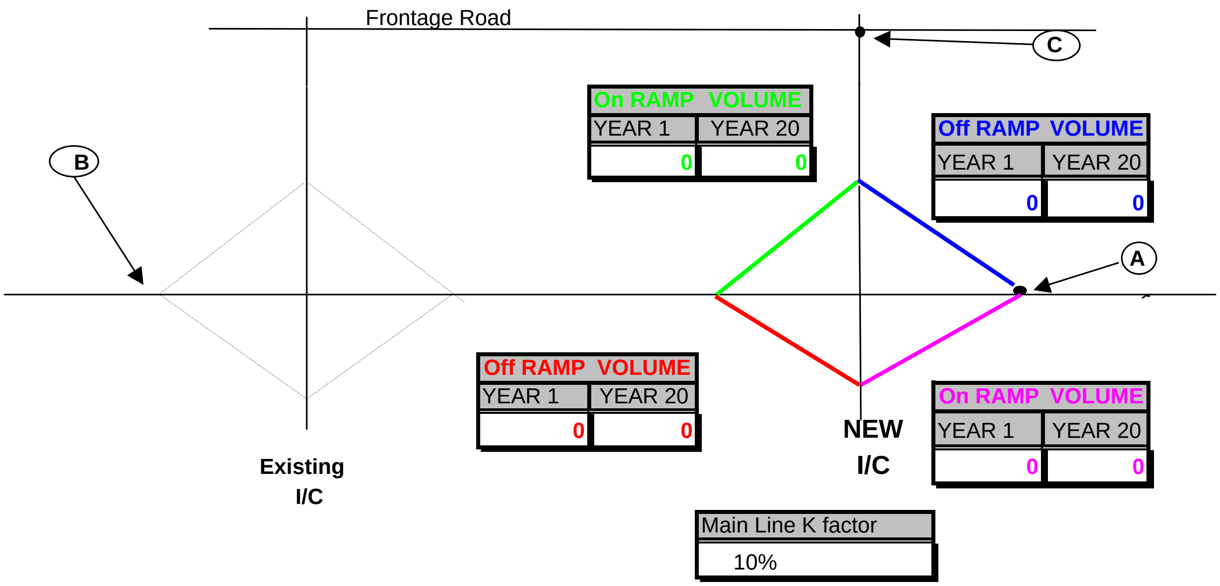
New Interchange at a NEW Access Point

Date: 04/19/00
SR: ________ **Analyst:** ____________
Project Title: ______________________________
Posted Speed: 60
Average Vehicle Occupancy : 1.3
% Trucks: 0.0%

Year 1 Daily / Peak Benefits Ratio: 1.3 Based on ADT % curve in Global Variables for an average of 2 hrs in AM & PM peak periods in Year 1.

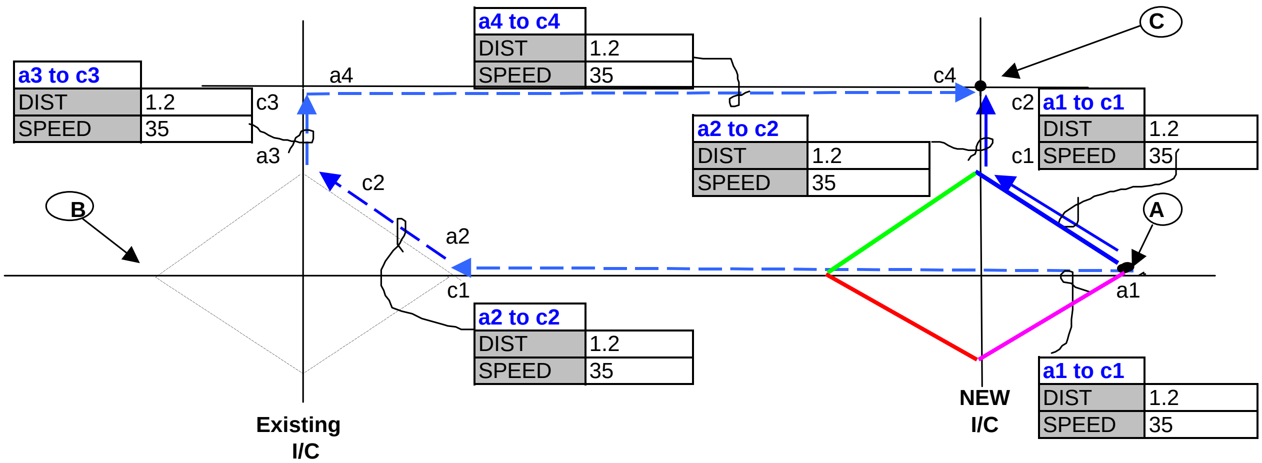
Year 20 Daily / Peak Benefits Ratio: 4.7 Based on ADT % curve in Global Variables for an average of 8 hrs in AM & PM peak periods in Year 20.

Input (ADT*K) or (DHV*peak adjust %) for the Working Peak Hour Volumes below.



ORIGIN A to DESTINATION C

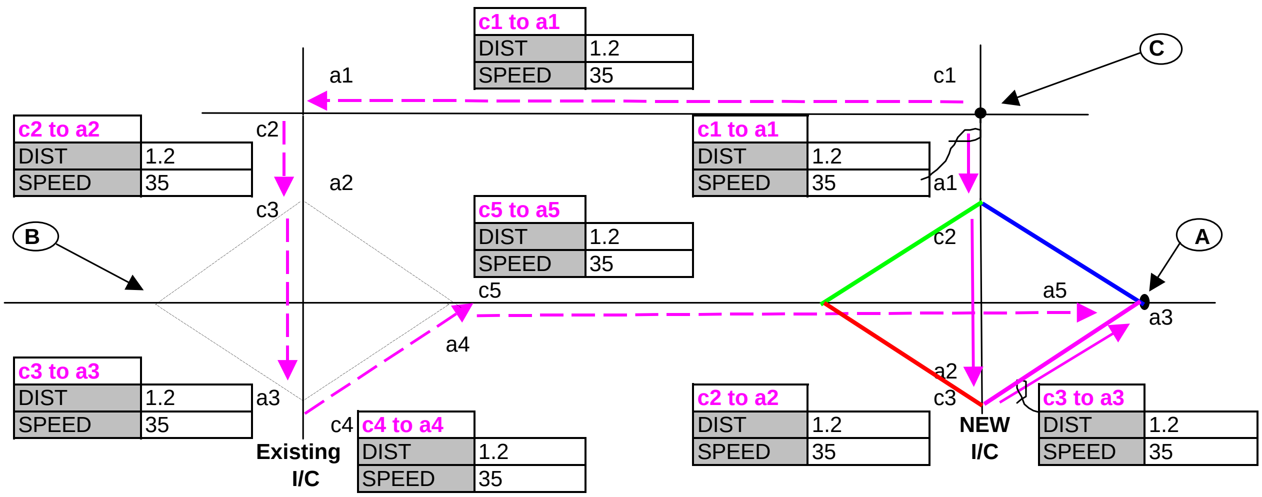
Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment				Build Segment			
	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
a1 to c1	35	1.2	0.034	3.82	35	1.2	0.034	1.1
a2 to c2	35	1.2	0.034		35	1.2	0.034	
a3 to c3	35	1.2	0.034				0.000	
a4 to c4	35	1.2	0.034				0.000	
a5 to c5			0.000				0.000	
a6 to c6			0.000				0.000	
a7 to c7			0.000				0.000	
a8 to c8			0.000				0.000	
a9 to c9			0.000				0.000	
a10 to c10			0.000				0.000	

ORIGIN C to DESTINATION A

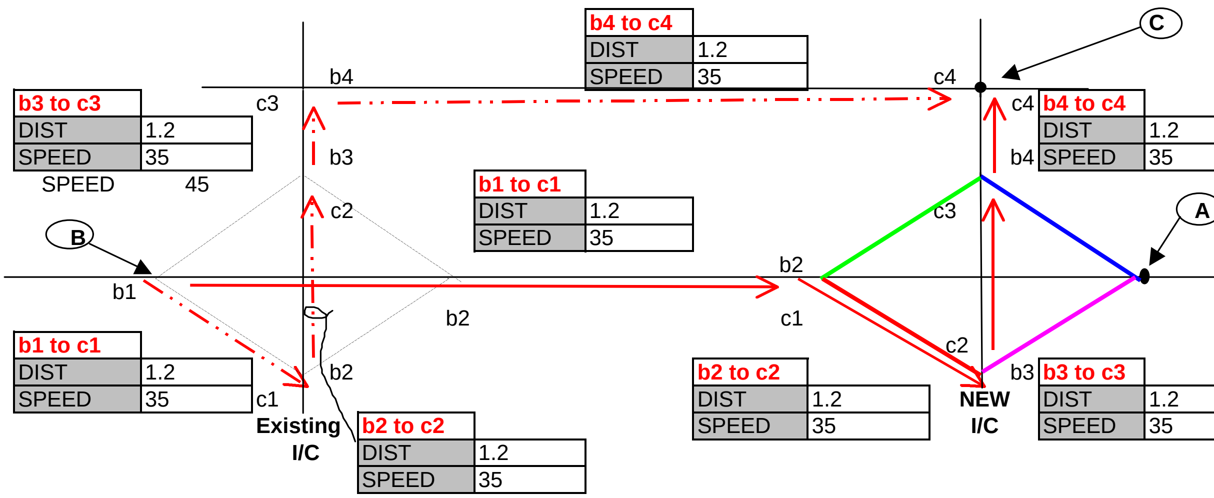
Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment: Speed mph	No Build Segment: Length mi.	No Build Segment: Calc.Trav. Time(Hrs)	No Build Segment: Model Travel Time(min)	Build Segment: Speed mph	Build Segment: Length mi.	Build Segment: Calc.Trav. Time(Hrs)	Build Segment: Model Travel Time(min)
c1 to a1	35	1.2	0.034	3.94	35	1.2	0.034	1.13
c2 to a2	35	1.2	0.034		35	1.2	0.034	
c3 to a3	35	1.2	0.034		35	1.2	0.034	
c4 to a4	35	1.2	0.034				0.000	
c5 to a5	35	1.2	0.034				0.000	
c6 to a6			0.000				0.000	
c7 to a7			0.000				0.000	
c8 to a8			0.000				0.000	
c9 to a9			0.000				0.000	
c10 to a10			0.000				0.000	

ORIGIN B to DESTINATION C

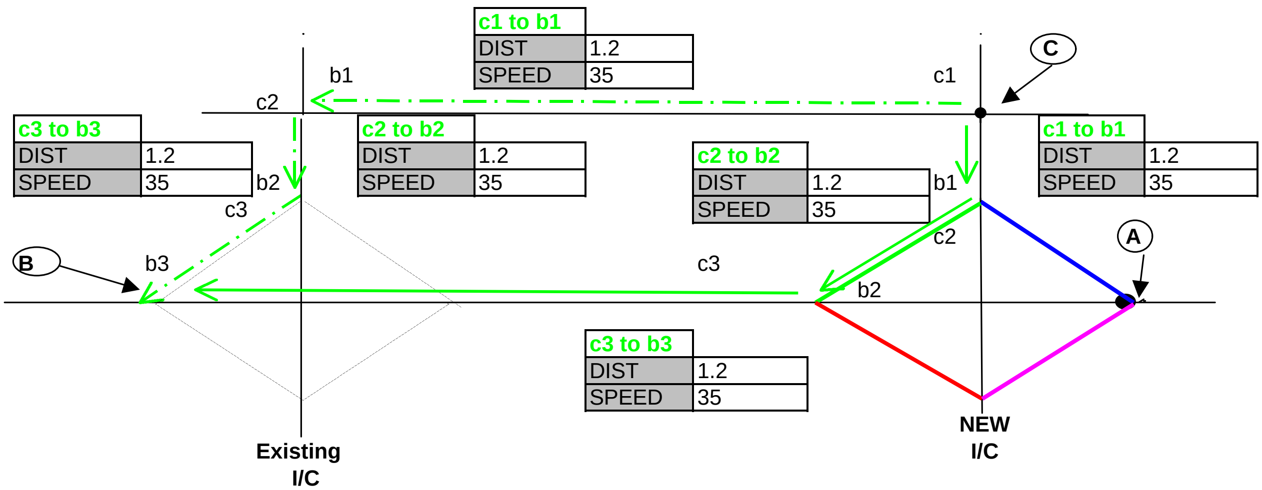
Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Build Segment Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
b1 to c1	35	1.2	0.034	2.89	35	1.2	0.034	1.28
b2 to c2	35	1.2	0.034		35	1.2	0.034	
b3 to c3	35	1.2	0.034		35	1.2	0.034	
b4 to c4	35	1.2	0.034		35	1.2	0.034	
b5 to c5	35	1.2	0.034				0.000	
b6 to c6			0.000				0.000	
b7 to c7			0.000				0.000	
b8 to c8			0.000				0.000	
b9 to c9			0.000				0.000	
b10 to c10			0.000				0.000	

ORIGIN C to DESTINATION B

Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment				Build Segment			
	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
c1 to b1	35	1.2	0.034	2.57	35	1.2	0.034	1.03
c2 to b2	35	1.2	0.034		45	0.3	0.007	
c3 to b3	35	1.2	0.034		35	1.2	0.034	
c4 to b4			0.000				0.000	
c5 tob5			0.000				0.000	
c6 to b6			0.000				0.000	
c7 to b7			0.000				0.000	
c8 to b8			0.000				0.000	
c9 to b9			0.000				0.000	
c10 to b10			0.000				0.000	

	Year 1 without improvement				Year 1 with improvement		
From / To	Volumes	Travel Time	Hours		Volumes	Travel Time	Hours
A to C	0	0.064	0.00	A to C	0	0.018	0.00
C to A	0	0.066	0.00	C to A	0	0.019	0.00
B to C	0	0.048	0.00	B to C	0	0.021	0.00
C to B	0	0.043	0.00	C to B	0	0.017	0.00
Total Hours			0.00				0.00

	Year 20 without improvement				Year 20 with improvement		
From / To	Volumes	Travel Time	Hours		Volumes	Travel Time	Hours
A to C	0	0.064	0.00	A to C	0	0.018	0.00
C to A	0	0.066	0.00	C to A	0	0.019	0.00
B to C	0	0.048	0.00	B to C	0	0.021	0.00
C to B	0	0.043	0.00	C to B	0	0.017	0.00
Total Hours			0.00				0.00

Peak Hour Travel Time

Year 1		Year 20	
Travel Time w/o imprvmnt	0.00	Travel Time w/o imprvmnt	0.00
Travel Time w/ imprvmnt	0.00	Travel Time w/ imprvmnt	0.00

Peak Hour Travel Time Savings (TTS)

TT(Build)-TT(No-Build)=TTS(Year 1 or 20)

Year 1			Year 20		
Travel Time Savings	0.00	Hrs	Travel Time Savings	0.00	Hrs

Peak Hour Travel Time Savings Distribution

Year 1		Year 20	
TTS - GP	0.00	TTS - GP	0.00
TTS - Truck	0.00	TTS - Truck	0.00

Daily User Benefits

Year 1	Year 20
$0	**$0**

Present Value Factor (PVF)

PVF = 0.00

Present Value of User Benefits

$0

High Occupancy Vehicle (HOV) Lane Benefits

Introduction

The HOV Lane worksheet is used to determine the travel time benefits of

- adding a 2+ designated high occupancy vehicle lane to an urban multilane highway or freeway; or
- converting a general purpose lane of an urban multilane highway or freeway to a 2+ designated high occupancy vehicle lane.

Assumptions

- Initially a 2+ HOV lane will be provided in either or both directions, based on user input.
- The year that the HOV volume = HOV capacity in either direction, the 2+ HOV lane(s) will be converted to 3+ lane(s) in either or both directions, based on user input.
- During the peak period, the HOV lane is only available to HOV vehicles.
- Outside of the peak period the HOV lane can be used for GP traffic.
- The posted speed is the same under build and no build conditions.

Worksheet Organization and Inputs

The user input and working area of the HOV Lane worksheets is divided into four sections:

- segment information;
- traffic volumes and composition;
- working peak hour operations and demand summaries; and
- annual user benefit calculations and summary.

The rest of the worksheet contains the details of the following calculations:

- working peak hour demand volumes for each year of the project life (usually 20 years); and

for Year 1, the conversion year (HOV2+ to HOV3+), and Year 20:

- 24-hour volume distribution;
- peak hour spreading;
- hourly volume-to-capacity ratios;
- hourly operating speeds;
- hourly travel time savings; and
- hourly user benefit estimates.

Data Inputs

In addition to the usual summary information that is copied into this worksheet from the "Estimate and B-C Ratio" worksheet, the following information will be needed:

- selected speed-flow curve (WSDOT default or HCM 2000 curves);
- general purpose lane and HOV lane capacities;
- number of general purpose and HOV lanes by direction, under build and no build conditions;
- Year 1 Volumes (2-way AWDT or working peak hour volumes by direction);
- Year 1 and Year 20 trucks percentages;
- general purpose lane and HOV volume growth rates; and
- traffic composition percentages, including peak period AVOs.

Worksheet Use

Segment Information

The segment information data section, located at the top of the spreadsheet, contains the general project information, some of which are copied from the "Estimate and B-C Ratio" worksheet and cannot be changed here. The user must input the following data in this section:

Speed-flow Curve. The user must select the speed-flow curve (WSDOT or HCM 2000) to be used to determine operating speeds. The default is the WSDOT curves. These curves are described in more detail in their own sections of this report.

Lane Capacities. The user must input the assumed lane capacities for general purpose lanes and HOV lanes.

Directional Number of Lanes. The user must input the number of lanes before and after the project, broken down by general purpose and HOV lanes.

Traffic Volumes and Composition

ADT or Working Peak Hour Volumes. The user must input the ADT volume OR a working peak hour volume. If the user inputs a 2-way ADT, this volume will be distributed to each hour of the day by direction based on the selected ADT volume distribution curve.

> *If input, the ADT volume will be used in the worksheet calculations. If the user desires the input working peak hour volume to be used in the calculations, the 2-way ADT volume should be left blank.*

Truck Percentages. The user should input the percent of total users who are truck operators for Year 1 and Year 20.

HOV and GP Volume Growth Rates. The user should input the growth rates to be used to extrapolate the HOV and GP volumes from Year 1 to Year 20.

Traffic Composition. The user must input the overall Year 1 traffic composition broken down by traffic that is only eligible for general purpose lanes and traffic that is eligible for HOV lane use, depending upon the HOV lane designation.

> *The traffic composition percents MUST add up to 100% for the worksheet to work properly. Since Excel defaults values less than one to percents automatically (an input of .2 becomes 20%) input percentages that are less than one with a preceding zero (i.e., input .2% as 0.2).*

Peak Period AVOs. The user must input the Year 1 and Year 20 peak period average vehicle occupancies for 4+ person, vanpool, public transit, and other bus modes.

Worksheet Calculations

Maximum Hourly Capacity

The worksheet can only handle volumes up to the maximum hourly capacity of the facility under build conditions. Therefore, in order to warn users if volume inputs exceed the limits of the methodology, a maximum hourly and daily capacity for the segment is estimated based on user input number of lanes, per lane capacity assumptions for general purpose and HOV lanes, traffic composition, and selected hourly distribution curves. The maximum hourly and daily capacities are then displayed for the user next to the volume inputs.

Peak Hour Demand Volumes

The beginning of Year 1 peak hour demand volumes are calculated from the user input ADT or working peak hour volumes. If the user has input an ADT estimate, this volume will be used with the selected 24-hour volume distribution curve to estimate the working peak hour volume. The hour with the highest percent of the ADT will be the working peak hour and this percent time the ADT will be the working peak hour volume. If the user inputs *only* working peak hour volumes for one or both directions, this volume will be considered the working peak hour volume and will be associated with the hour with the highest percent of the ADT (based on the user selected 24-hour volume distribution curve.

The end of Year 1 eligible HOV 2+ and 3+ volumes and general purpose lane volumes are estimated using equations from FHWA's QuickHOV program[5]. Once Year 1 volumes have been estimated, the working peak hour HOV and general purpose demands are forecasted for each year based on the HOV and the volume growth rates input by the user.

If the HOV demand exceeds the capacity of the lane in any year, then the HOV lane is assumed to transition to a minimum 3+person HOV lane at the end of that year.

HOV Estimates

The first year eligible HOV 2+ and 3+ volumes are estimated using the following equation from FHWA's QuickHOV program:

$$HOV_{After} = HOV_{Before} + HOV_{Before} * \left[0.13 + 2.11 \left(\frac{HOVTIME_{Before} - HOVTIME_{After}}{HOVTIME_{Before}} \right) \right]$$

The HOV_{After} volumes are the estimated number of vehicles eligible to use the HOV 2+ and/or 3+ lanes at the end of the first year. These values will be calculated using the equation above.

The HOV_{Before} volumes are the number of year "zero" vehicles that would be eligible to use the HOV 2+ and/or 3+ lanes, if they existed. These values are estimated from the total volume and vehicle mix percentages provided by the user.

The $HOVTIME_{Before}$ is the mixed flow lane mean travel time (hours) in year "zero", before the HOV lane has opened. This value is equal to the value the mean travel time before the HOV lane opens in vehicle hours divided by the mean number of vehicles eligible to use the HOV lane.

The $HOVTIME_{After}$ is the HOV lane mean travel time (hours) on the day that the HOV lane is opened (before the HOV_{After} demand is computed). The $HOVTIME_{After}$ is computed assuming all eligible HOV_{Before}'s use the HOV lane and there are no SOV violators in the lane. This value is equal to the value the mean travel time after the HOV lane opens in vehicle hours divided by the mean number of vehicles eligible to use the HOV lane.

[5] R. G. Dowling, J. Billheimer, V. Alexiadis, and A.D. May, Predicting the Demand for High Occupancy Vehicle (HOV) Lanes, Federal Highway Administration Project #42-10-4172, Washington D.C., June 1996.

NONHOV Estimates

The first year NONHOV volumes are estimated using the following equation from FHWA's QuickHOV program:

$$NONHOV_{After} = NONHOV_{Before} + NONHOV_{Before} * \left[0.48 \left(\frac{NONHOVTIME_{Before} - NONHOVTIME_{After}}{NONHOVTIME_{Before}} \right) \right]$$

The $NONHOV_{After}$ volume is the number of vehicles assumed to be using the general purpose lanes at the end of the first year.

The $NONHOV_{Before}$ volume is the number of year "zero" vehicles that would NOT be eligible to use an HOV lane if one existed. This value is estimated from the total volume and vehicle mix percentages provided by the user.

The $NONHOVTIME_{Before}$ is the mixed flow lane mean travel time (hours) in year "zero", before the HOV lane has opened. This value is equal to the value the mean travel time before the HOV lane opens in vehicle hours divided by the mean numb er of non-HOV vehicles.

The $NONHOVTIME_{After}$ is the mixed flow lane mean travel time (hours) on the day that the HOV lane is opened (before the HOV_{After} demand is computed). The $NONHOVTIME_{After}$ is computed assuming all eligible HOV_{Before}'s use the HOV lane and there are no SOV violators in the lane. This value is equal to the value the mean travel time in the general purpose lanes after the HOV lane opens in vehicle hours divided by the mean number of non-HOV vehicles.

New Users

The difference between the HOV_{Before} volumes and the first year HOV_{After} volumes, and the $NONHOV_{Before}$ volumes and the first year $NONHOV_{After}$ volumes will be considered to be "new" users of the facility that come from other modes, other time periods, or other routes.

Conversion Year (HOV 2+ to HOV 3+ Designation)

One hundred percent of all eligible HOVs are assumed to use the HOV lane until the HOV demand exceeds the capacity of the HOV lane(s). It is assumed that once the HOV demand exceeds the capacity of the HOV lane(s), the HOV lane will be converted to a 3+ persons HOV lane at the *end* of that year. This year will be considered the Conversion Year. The Conversion Year may be equal to Year 1 or Year 20. If the HOV lane was already limited to 3+ persons per vehicle, then some of the HOV3+ demand is shifted to the general purpose lanes so as to ensure that the speed in mixed flow lanes is not greater than HOV lane.

Hourly Demands

The Year 1, Conversion Year, and Year 20 build and no build hourly demands are estimated using the user selected 24 hour distribution curves. The Conversion Year 24-hour distribution curve is estimated based on interpolation of the Year 1 and Year 20 24-hour distribution curves. The working peak hour volume is assumed to be associated with the hour with the highest percent of the ADT. Demand volumes for each of the other hours of the day are estimated by multiplying the working peak hour volume by the percent ADT in the hour divided by the highest percent ADT (i.e. the working peak hour) in the selected 24-hour volume distribution curve.

Peak Hour Spreading

If any Year 1, Conversion Year, and/or Year 20 build and no build hourly HOV and/or general purpose lane demands exceed the capacity of these facilities, excess volumes are redistributed as discussed in the Capacity Constraint and Peak Spreading section of this report (see Page 1).

Volume-to-Capacity Ratios

Year 1, Conversion Year, and Year 20 no build and build volume-to-capacity ratios are calculated by dividing the resultant hourly demands by the appropriate facility capacity. Since peak hour spreading was cursorily handled above, no v/c ratio will be greater than 1.0 for HOV lanes and 1.2 for general purpose lanes.

Mean Operating Speeds

Mean operating speeds are determined for each hour based on the selected speed-flow look-up tables and the computed volume/capacity ratio for the build and no-build conditions for Year 1, Conversion Year, and Year 20.

Travel Time Savings

Hourly travel times are estimated for Year 1, Conversion Year, and Year 20 build and no build conditions by dividing the length of the facility by the mean operating speed and multiplying by the volume. The vehicle-hours of travel (VHT) for the mixed flow (general purpose) lanes are split between trucks and non-trucks.

All of the HOV lane VHT is assigned to the HOVs. The travel time savings for HOV will be split into two components, that of the "existing HOVs", and the "new HOVs", as described above.

User Benefits

The cumulative user benefits for Year 1, the Conversion Year, and Year 20 are computed using the travel time savings and cost parameters, and are estimated individually for the analysis period when the HOV lane is designated as 2+ persons and the analysis period when the HOV lane is designated as 3+ persons.

The benefit computations apply the economic "rule of half" to the estimated travel time savings for the "new" HOVs using the facility. The travel time savings for existing HOVs is not discounted.

The estimate of working peak hour benefits is estimated by the following equation:

$$Benefits_{HOV} = TTS_{HOV} * \left[EX_{HOV} + \frac{NEW_{HOV}}{2} \right] * CP_{HOV} * AVO_{HOV}$$

where:

BenefitsHOV = Total HOV benefits ($)

TTSHOV = Overall HOV Travel Time Savings (hrs per vehicle)

EXHOV = volume that was HOV eligible before project (HOV_{Before})

NEWHOV = volume that was not HOV eligible before project (HOV_{After} - HOV_{Before})

CP_{HOV} = HOV user cost parameter ($ / user)

AVO_{HOV} = Average number of users per HOV vehicle (users / veh)

The resultant present value benefits are estimated using the discount rate contained in the worksheet and a present value factor as discussed in the Benefits Computation section of this document. This value is then transferred into Estimate and B-C Ratio worksheet.

Reports

The print area in the HOV worksheet is set up to generate a three-page report. The first page lists the input data, including the calculated maximum hourly capacity of the facility. The second page shows the working peak hour operations and demand summaries for Year 1, the Conversion Year, and Year 20, including the year that the mixed flow and HOV lane demands exceed capacity under build and no build conditions. The third page summarizes the user benefits computation by direction and the resultant total present value of the benefits. This report is shown on the next three pages.

HOV CAPACITY IMPROVEMENT WORKSHEET

Notes on use of worksheet:

1) This worksheet evaluates the addition of a 2+ HOV lane, or conversion of a GP lane to a 2+ HOV lane, by direction.
2) Worksheet assumes that a 2+ lane will be provided until the year HOV volume = HOV capacity, then 2+ lane is converted to 3+ lane.
3) Worksheet assumes that HOV lane is in operation during peak period and can be used for GP traffic outside of peak period.
4) User must input all values denoted by a [ ]
5) Worksheet will use ADT volume, if input. If entering working peak hour volumes, input peak (maximum) volume by direction, even if for different hours of the day.

Date: 04/19/2000
Analyst:

Resultant Benefits ($000s):
HOV2+ = $0.0, HOV3+ = $0.0, Total = $0.0

SEGMENT INFORMATION

State Route:
Project Title:
Posted Speed (50, 60, or 70mph): 60
Begin & End Mileposts: 0.00 & 0.00
Length of Section: 0.00 miles

GP Cap/Lane: 2,200 — Default = 2,200 vphpl
HOV Cap/Lane: 1,500 — Default = 1,500 vphpl
Speed Curve: WSDOT Default

Number of Lanes:	GP	HOV	Total	GP Capacity	HOV Capacity	Total Capacity
NO BUILD NB/WB:		0	0	0	0	0
NO BUILD SB/EB:		0	0	0	0	0
BUILD NB/WB:			0	0	0	0
BUILD SB/EB:			0	0	0	0

Analysis period (yrs): 20
Value of Benefits to New Users: 1/2 — Default is 1/2. To change, edit cell '[MPPPbc.xls]Global Variables'!$B$26.

PEAK HOUR TRAFFIC VOLUMES AND COMPOSITION

Traffic Demand Source:

	Year 1	Year 20
Select ADT % Curve:	SR 4, MP 62.21	SR 4, MP 4.75
AM Peak Period:	7 AM to 8 AM	6 AM to 10 AM
PM Peak Period:	4 PM to 5 PM	3 PM to 7 PM

Number of hours HOV lane is at capacity in Year 20

	NB/WB	SB/EB
AM	No HOV Lane	No HOV Lane
PM	No HOV Lane	No HOV Lane

Number of hours that HOV lane is at capacity is based on hourly volumes that have been adjusted to account for peak spreading.

	Year 1	Est. Capacity	Year 20 No Build	Year 20 Build
Average Daily Traffic (vpd):		0	0	0
Working Pk. Hr. Vol. (vph) NB/WB:		0		
Working Pk. Hr. Vol. (vph) SB/EB:		0		
Truck Percentage, Year 1:				
HOV Growth Rate:				
GP Growth Rate:				

Truck Percentage, Year 20: 0.0%

1) No Build demands extrapolated using straight-line growth assumptions.
2) Year 1 Build demands based on Quick HOV equations.
3) Subsequent year Build demands are extrapolated.
4) HOV 2+ converts to HOV 3+ when HOV 2+ volumes >= HOV capacity.
5) First year converted facility demands are based on Quick HOV eqns.

Traffic Composition	Peak Hour %	Peak Period AVO (Year 1)	Peak Period AVO (Year 20)	HOV 2+ Proportion	HOV 3+ Proportion
SOV/GP Eligible Only	85.0%				
Trucks		1.00	1.00		
Non-Trucks		1.30	1.30		
HOV Eligible	15.0%				
2 person	10.0%	2.00	2.00	0.667	
3 person	4.0%	3.00	3.00	0.267	0.800
4+ person	0.2%	4.10	4.10	0.013	0.040
vanpool	0.2%	8.00	8.00	0.013	0.040
public transit	0.2%	30.00	60.00	0.013	0.040
other bus	0.2%	8.00	8.00	0.013	0.040
motorcycle	0.2%	1.00	1.00	0.013	0.040
	HOV 2+ Designation AVO :	2.81	3.21	67%	33%
	HOV 3+ Designation AVO :	4.44	5.64		

Assumptions:

1) Traffic composition for base and future years is based on the current compositions of the corridor, as provided by the user.

2) Bus occupancy in linear and is = 60 people in Year 20.

3) All 2-person carpools will convert to 3+ vehicle as the the minimum occupancy requirement is increased.

4) The HOV AVO is calculated assuming a weighted average (I.e. the sum of products on proportions of total HOV * individual AVOs)

WORKING PEAK HOUR OPERATIONS AND DEMAND SUMMARIES

Working Peak Hour Operations		**Year when V/C >= 1.00** NB/WB	SB/EB	**Comments**
No Build Conditions				
	All Lanes (Mixed Flow)	After Year 20	After Year 20	
Build (HOV 2+) Conditions				
	Mixed Flow Lanes	After Year 20	After Year 20	
	HOV 2+ Lane	No HOV Lane	No HOV Lane	
Build (HOV 3+) Conditions				
	Mixed Flow Lanes	After Year 20	After Year 20	
	HOV 3+ Lane	No HOV Lane	No HOV Lane	

Northbound / Westbound

Working Peak Hour Volumes		**Begin First Year Demands** BEGIN YR 1	**End First Year Demands** END YR 1	**Year HOV Lane Converts to 3+** END YR 1	**Year HOV Lane Benefits End** END YR 20	Comments
HOV Growth Rate	0.00%	*(no build)*	*(w/No HOV lane)*	*(w/No HOV lane)*	*(w/No HOV lane)*	With HOV demands based on QuickHOV demand equations
GP Growth Rate	0.00%					
Peak Hour Volume (GP+HOV)		0	0	0	0	
Peak Hour Volume (GP Only)		0	0	0	0	
2+ HOV Eligible Percentage		15.0%				
2+ HOV Eligible Volumes		0				**No HOV lane is this direction**
3+ HOV Eligible Percentage		5.0%	100.0%	100.0%	100.0%	
3+ HOV Eligible Volumes		0	0	0	0	
HOV Volumes (HOV eligible under Build conditions)		**0**		**0**		Based on capacity constraint
Assigned HOV Min. Designation (No HOV, 2+, 3+)		**No HOV**	**No HOV**	**No HOV**	**3+ after Yr 1**	

Southbound / Eastbound

Working Peak Hour Volumes		BEGIN YR 1	END YR 1	END YR 1	END YR 20	Comments
HOV Growth Rate	0.00%	*(no build)*	*v/HOV No HOV lane*	*v/HOV No HOV lane*	*(w/No HOV lane)*	With HOV demands based on QuickHOV demand equations
GP Growth Rate	0.00%					
Peak Hour Volume (GP+HOV)		0	0	0	0	
Peak Hour Volume (GP Only)		0	0	0	0	
2+ HOV Eligible Percentage		15.0%				
2+ HOV Eligible Volumes		0				**No HOV lane is this direction**
3+ HOV Eligible Percentage		5.0%	100.0%	100.0%	100.0%	
3+ HOV Eligible Volumes		0	0	0	0	
HOV Volumes (HOV eligible under Build conditions)		**0**		**0**		Based on capacity constraint
Assigned HOV Min. Designation (No HOV, 2+, 3+)		**No HOV**	**No HOV**	**No HOV**	**3+ after Yr 1**	

Assumptions:

HOV percentages include all eligible HOV users, including motorcycles. SOV percentages include all trucks.

HOV percentages for No Build are based on the current composition of the corridor; Build HOV percentages are based on Quick HOV equations for Year 1.

USER BENEFIT CALCULATION AND SUMMARY

Translate travel time saving estimates into user benefits using the following equation:

Annual Benefits = Benefits to Existing Users + Benefits to New Users

Benefits to Existing Users = (Travel Time Savings MF**ex** * (1-PctTrucks) * Cost Parameter Non-Trucks * AVO Non-Trucks * Peak Hours/Day * Days/Year) +
(Travel Time Savings MF**ex** * (PctTrucks) * Cost Parameter Trucks * AVO Trucks * Peak Hours/Day * Days/Year) +
(Travel Time Savings HOV**ex** * Cost Parameter HOV * AVO HOV * Peak Hours/Day * Days/Year)

Benefits to New Users = (Travel Time Savings MF**new** * (1-PctTrucks) * Cost Parameter Non-Trucks * AVO Non-Trucks * Peak Hours/Day * Days/Year) * **BENnew** +
(Travel Time Savings MF**new** * (PctTrucks) * Cost Parameter Trucks * AVO Trucks * Peak Hours/Day * Days/Year) * **BENnew** +
(Travel Time Savings HOV**new** * Cost Parameter HOV * AVO HOV * Peak Hours/Day * Days/Year) * **BENnew**

where:

All values below based on Global Variables worksheet or data provided by user at top of this worksheet

Cost Parameter Non-Trucks =	$10.00	per vehicle	AVO non-trucks =	1.3	persons/vehicle
Cost Parameter HOV =	$10.00	per vehicle	AVO trucks =	1.0	persons/vehicle
Cost Parameter Trucks =	$50.00	per vehicle	AVO HOV =	2.81 to 5.64	persons/vehicle
Annual / Daily Benefit Ratio =	260	days / year	BENnew =	1/2	new / old benefits

Default for BENnew is 1/2 based on the economic 'rule of half'. To change, edit cell '[MPPPbc.xls]Global Variables'!$B$26 in Global Variables.

HOV 2+ User Benefit Calculation		HOV 3+ User Benefit Calculation		
Build HOV 2+ (Year 1) User Benefits	$0	Build HOV 3+ User Benefits	$0	
Year 1 User Benefits	$0	Year 20 User Benefits	$0	
Year 1 / Build HOV 2+ User Benefits	0.00	Year 20 / Build HOV 3+ User Benefits	0.00	
Annual Growth Rate, r	0.00	Annual Growth Rate, r	0.00	= [ln(Year End Benefits / Year Begin Benefits) / # of Years]
Analysis Period, n	0	Analysis Period, n	20	
Discount Rate, i	0.04	Discount Rate, i	0.04	
Present Value Function (PVF)	0.00	Present Value Function (PVF)	13.77	= [(exp((r-i)n)-1)/(r-i)]
HOV 2+ Present Value of Benefits	**$0**	**HOV 3+ Present Value of I**	**$0**	= PVF * Year Begin Benefits
			$0	= HOV2 PVb + HOV3 PVb

Park and Ride Lot Benefits

Introduction

The park-and-ride lot worksheet is used to determine the user benefits that result from constructing a new park-and-ride lot adjacent to a state highway. The worksheet has been designed to accommodate a variety of potential park-and-ride lot types and locations. As a result, not all of the requested inputs may be needed for a given site.

If the proposed park-and-ride lot will be constructed next to a freeway with HOV facilities, users should use the HOV lane spreadsheet to determine the average speed of the HOV and general purpose lanes.

Assumptions

All lot users are assumed to arrive at the lot during the AM peak hour and return during the PM peak hour.

The lot is assumed to reach capacity in the first year. Future enhancements of the software may allow the user to define the year that the lot reaches capacity. A placeholder is in the current software, but no formulas reference this cell at this time.

Worksheet Organization and Inputs

The park-and-ride worksheet is divided into five sections:

- summary information;
- destination data;
- time savings calculation;
- out-of-pocket cost savings calculation; and
- user benefit calculation.

The worksheet allows information for up to five potential destinations to be entered. Identical sections for destinations #2-5 are located to the right of the section for destination #1. User benefits are calculated by destination; to calculate the total lot benefit, manually sum the benefits for each destination.

In addition to the usual summary information that is copied into this worksheet from the "Project Information" and "Global Variables" worksheets, the following information must be provided for each lot:

- number of parking spaces provided;
- number of walk-in and bike-in users in Year 20;
- year lot reaches capacity (not in operation in this version of software); and
- percent of lot capacity used in Year 1 and Year 20.

Additional required and optional information can be provided for each destination served by the lot. Each lot must have at least one destination; up to five destinations can be analyzed.

- destination name (required)
- percent of lot users traveling to the destination (required)
- destination distance from the park-and-ride (required)
- average general purpose lane speed (required)
- HOV information (optional)
  - miles of HOV lanes between the park-and-ride lot and the destination
  - average HOV lane speed
- transit information (optional)
  - express transit headway
  - local transit travel time to destination
  - monthly transit express pass cost
  - monthly transit local pass cost
- carpool information (optional)
  - average carpool size
  - average carpool wait time
- average monthly parking cost at destination (optional)

Travel time benefits are calculated as twice the one-way benefit. If conditions are different between the inbound direction during the AM peak hour and the outbound direction during the PM peak hour (different HOV lane lengths, different travel speeds, etc.), use the average of the two situations.

Worksheet Use

Summary Data

The summary data section, located at the top of the spreadsheet, contains general project information. Enter user-supplied project information once in the area above "Destination #1 Data." This information will be copied automatically to the other four destinations. Blue-shaded cells contain values copied from the "Project Information" and "Global Variables" spreadsheets and cannot be changed here. Project information that must be entered in the Park-and-Ride worksheet is listed below.

Number of Parking Spaces. Enter the number of marked parking spaces provided. This number is assumed to be constant over the 20-year analysis period.

Number of Walk/Bike Users (Year 20). If the lot will be located next to residential uses that could supply walk-up or bike-up users, enter the estimated number of future users in this cell and supply the basis for the estimate on a separate sheet of paper.

Percent of Lot Capacity Used. Enter the percent of lot capacity expected to be used in Year 1 and Year 20. Growth is assumed to occur linearly between Year 1 and Year 20. If local experience indicates that parking occurs outside of marked stalls when the lot reaches capacity, a value above 100% may be entered, but should be justified.

Year Lot Reaches Capacity. Not currently used.

Destination Data

Enter information about each destination in the designated sections. Destinations #2-5 are located to the right of Destination #1 on the worksheet.

Destination Name. Enter the name of the destination that the information applies to.

Percent of Lot Users to this Destination. Enter the percentage of arriving vehicles and walk-up/bike-up customers that travel to this destination. The sum of the percentages for destinations #1-5 must total 100%. An error message will be displayed if the sum is not 100%.

Distance from Park & Ride. Enter the travel distance (in miles) between the lot and the destination.

Miles of HOV Lanes to Destination. Enter the miles of HOV lanes that exist along the travel route between the lot and destination. If there are no HOV lanes, enter zero. An error message will be displayed if the miles of HOV lanes are greater than the destination distance from the lot.

Average HOV Lane Speed. Enter the average speed (in mph) of the HOV lane sections between the lot and the destination. If there are no HOV lanes, enter the average general purpose lane speed, instead. Attach the HOV lane worksheet used to estimate the speed. An error message will be displayed if the HOV lane speed is less than the general purpose lane speed.

Average General Purpose Lane Speed. Enter the average speed (in mph) of the general purpose lanes between the lot and the destination.

Express Transit Headway. Enter the average peak-hour express transit headway (in minutes) between the lot and the destination. This value is used to estimate how far in advance of a bus departure that users will arrive at the lot. Leave the cell blank if there is no express transit service from the lot. Express transit service is assumed to use the adjacent highway non-stop to the destination.

Local Transit Travel Time to Destination. Enter the scheduled travel time between the lot and the destination by local transit (transit service that stops between the lot and the destination). This value is used to estimate the time savings of existing transit passengers that switch to new express service provided when the lot opens.

Monthly Transit Express Pass Cost. Enter the average cost of an express transit pass from the lot to the destination. If the destination is a single large employer or a group of employers that have formed a transportation management association (TMA), deduct the average transit subsidy provided by the employer(s).

Monthly Transit Local Pass Cost. Enter the average cost of a local transit pass from the lot to the destination. If the destination is a single large employer or a group of employers that have formed a TMA, deduct the average transit subsidy provided by the employer(s).

Average Carpool Size. Enter the average size of the carpools and vanpools departing the lot.

Average Carpool Wait Time. Enter the average time that carpoolers/vanpoolers arrive at the lot in advance of their departure.

Monthly Parking Cost at Destination. Enter the average monthly cost for parking at the destination. If employers typically provide subsidies, deduct the value of the subsidy. If free parking is provided, enter zero.

Worksheet Calculations

Time Savings Calculation

This section calculates the time saved (or lost) per trip (inbound or outbound) by different categories of lot users. The worksheet defines four categories of lot users.

New Transit Riders are former SOV drivers who switch to express transit service made available in conjunction with the new park-and-ride. The group's time savings is equal to the difference in HOV and general purpose lane travel times, minus their wait time at the lot for the bus. If there are no HOV lanes, new transit riders will experience a time loss equal to the wait time (half the express transit headway if ten minutes or less; otherwise, the square root of the express transit headway).

Old Transit Riders are existing local transit riders who switch to express transit service when it is made available in conjunction with the new lot. The group's time savings is equal to the difference between the local and express transit travel times between the lot and the destination. Old transit riders experience no change in wait time, since they were already riding transit.

New Carpoolers are former SOV drivers who switch to carpooling as a result of the new lot. The group's time savings is equal to the difference in HOV and general purpose lane travel times, minus their wait time at the lot for all of their carpool to show up. If there are no HOV lanes, new carpoolers will experience a time loss equal to the user-provided carpool wait time.

Old Carpoolers are existing carpoolers who switch to the new lot for convenience. They experience no overall change in travel time.

Out-of-Pocket Cost Savings Calculation

This section calculates the net change in out-of-pocket costs to lot users as a result of switching modes.

New Transit Riders have an express transit pass cost that they did not have as SOVs, but save the full amount of monthly parking and vehicle operating costs.

Old Transit Riders pay the difference between local and express transit passes (if any) and have no change in parking and vehicle operating costs, since they were already riding transit.

New Carpoolers have no transit pass costs, and save a portion of their former parking and vehicle operating costs. Costs are assumed to be allocated equally between all members of the carpool.

Old Carpoolers have no change in out-of-pocket costs.

User Benefit

The last section calculates the daily user benefit to the destination and converts it to an annual benefit. You'll need to specify the proportion of users to the destination that fall into each of the four categories (new transit riders, old transit riders, new carpoolers, and old carpoolers), which must total 100% for each destination. You'll also need to specify the average vehicle occupancy to the lot for each user type, which is used to convert vehicles (parking spaces used) into persons. The worksheet takes the percent of lot capacity used into account when determining benefits, as well as the number of walk-up/bike-up customers. The annual user benefit is twice the daily peak direction time savings multiplied by the annual/daily benefit ratio plus 12 times the monthly out-of-pocket cost savings.

> *If "ERROR" appears in the lower right corner of the worksheet, one or more of your entries needs to be revised. Scroll back up the worksheet and look for error messages in the right column that will indicate the cause of the problem.*

Reports

The print area in the Park and Ride worksheet is set up to generate a one-page report showing the destination data and travel time savings and user benefit calculations for Destination #1 only. This report is shown on the next page.

> *If the user wants to print out data for Destinations #2, #3, #4 or #5, the user should select the page of data for each of the Destinations independently, and then print the user selection by using the* ***File*** *pull down menu,* ***Print…*** *and then choosing to print* ***Selection.***

PARK & RIDE LOT

SR:		**Date:**	04/19/2000
Project Title:		**Analyst:**	
Milepost:	0.00		
Number of Parking Spaces:			
Number of Walk/Bike Users (Year 20):			
Percent of Lot Capacity Used (Year 1):		**Year 20:**	
Year Lot Reaches Capacity (1-20+):			
Vehicle Operating Cost:	$0.07 **$/mi**		
Annual / Daily Benefit Ratio:	260		

Destination #1 Data

Destination Name:			
Percent of Lot Users to this Destination:	0%		Destinations must sum to 100%
Distance from Park & Ride:		**mi**	
Miles of HOV Lanes to Destination:		**mi**	enter 0 if no HOV lanes
Average HOV Lane Speed		**mph**	same as GP lanes if no HOV lanes
Average General Purpose Lane Speed:		**mph**	
Express Transit Headway:		**min**	leave blank if no express transit service
Local Transit Travel Time to Destination:		**min**	leave blank if no local transit service
Monthly Transit Express Pass Cost:	$0.00		deduct value of average employer subsidy
Monthly Transit Local Pass Cost:	$0.00		deduct value of average employer subsidy
Average Carpool Size:		**persons**	
Average Carpool Wait Time:		**min**	
Monthly Parking Cost at Destination:	$0.00		deduct value of average employer subsidy

Time Savings Calculation

	Transit Riders		Carpoolers		
	New	**Old**	**New**	**Old**	
Travel Time Savings:	0.00	0.00	0.00	0.00	**min/trip**
Wait Time:	0.00	0.00	0.00	0.00	**min/trip**
Net Travel Time Savings:	0.00	0.00	0.00	0.00	**min/trip**

Out-of-Pocket Cost Savings Calculation

	Transit Riders		Carpoolers		
	New	**Old**	**New**	**Old**	
Transit Pass Cost:	$0.00	$0.00	$0.00	$0.00	**$/month**
Parking Cost Savings:	$0.00	$0.00	$0.00	$0.00	**$/month**
Vehicle Operating Cost Savings:	$0.00	$0.00	$0.00	$0.00	**$/trip**

User Benefit

	Transit Riders		Carpoolers		
	New	**Old**	**New**	**Old**	
User Distribution to this Destination:	35%	25%	5%	35%	
Value of Time:	$10.00	$10.00	$10.00	$10.00	**$/h**
Average Vehicle Occupancy To Lot:	1.0	1.0	1.0	1.3	**persons**
Annual Peak Direction Time Savings:	$0	$0	$0	$0	
Annual Out-of-Pocket Savings:	$0	$0	$0	$0	**Total**
Annual Daily User Benefit, Year 1:	$0	$0	$0	$0	$0
= Peak Time Savings*(Daily/Peak Ratio)+Out-of-Pocket Savings					

User Benefit, Year 20:	= Year 1 Benefits * (Year 20 Lot Percent / Year 1 Lot Percent)	$0
Year 20 / Year 1 User Benefits		0.00
Annual Growth Rate, r	= [ln(Year 20 Benefits/Year 1 Benefits) / # of Years]	0.00
Analysis Period, n		20
Discount Rate, i		4.0%
Present Value Function (PVF)	= [(exp((r-i)n)-1)/(r-i)]	13.77

Present Value of User Benefits: $0

ERROR

Present Value of User Benefits: $0

Safety Benefits

Introduction

Accident benefits are based solely on expected accident reductions due to the proposed improvements. Each accident that can be alleviated is categorized in one of five categories and assigned benefits based on the societal costs of each category.

Worksheet Organization and Inputs

The worksheet allows the user to evaluate up to five concurrent safety improvements for a particular analysis segment. The accident reduction factors are automatically calculated from look-up charts located within the spreadsheet.

Data Inputs

- type of safety improvement
- # of accidents from the previous 3-year period in the following categories.
  - Fatality
  - Disabling Injury
  - Evident Injury
  - Possible Injury
  - Property Damage Only

Worksheet Calculations

The worksheet calculates the accident savings for the proposed improvement over a 20-year analysis period. The following societal costs are used in the benefit calculations.

Table 7. Accident Costs

Accident Type	**Societal Cost**
Fatality	$800,000
Disabling Injury	$800,000
Evident Injury	$62,000
Possible Injury	$33,000
Property Damage Only	$5,800

Reports

The print area in the Safety worksheet is set up to generate a one-page report showing the accident savings and safety improvement calculations. This report is shown on the next page.

SAFETY BENEFITS

ACCIDENT SAVINGS-SAFETY PROJECTS

SR ______ **Posted Speed:** 60

Project Title:

Subject Section: **MP** 0 **to** **MP** 0

Length of Subject Section: 0 **Miles**

Number of Lanes: **No - Build** 0 **Build** 0

Safety Improvement

1)

2)

3)

4)

5)

Annual safety Benefits in Number of Collisions: Three (3) Year Study Period

Collision Type	(factor)	Total Acc.	Ann. Acc	Ann. Benefit
a) Fatality (2)	0.00	0	0.00	0.00
b) Disabling injury (5)	0.00	0	0.00	0.00
c) Evident Injury (6)	0.00	0	0.00	0.00
d) Possible Injury (7)	0.00	0	0.00	0.00
e) PDO (1)	0.00	0	0.00	0.00

Costs Per Collision(FHWA-RD-91-005)

Collision Type	Costs
a) Fatality	$800,000
b) Disabling injury	$800,000
c) Evident Injury	$62,000
d) Possible Injury	$33,000
e) PDO	$5,800

Annual Safety Benefits by Costs of Collisions

a) Annual Benefit*Cost= $0

b) Annual Benefit*Cost= $0

c) Annual Benefit*Cost= $0

d) Annual Benefit*Cost= $0

e) Annual Benefit*Cost= $0

f) Total, (B) = $0

Service Life,(n) = 20 Salvage Value, (T) = 0 Interest Rate, (i) = 0.04

Present Worth of Cost, PWOC:

a) Present Worth Factor, PWni 0.46

b) Present Worth Factor, of a Uniform Service, SPWin 13.59

Present Worth of Benefits, PWOB = B (SPWin) $0

WSDOT Default Speed-Flow Curves

The accepted WSDOT policy direction is for the default speed-flow curves to be based on the 1965 Highway Capacity Manual. The lookup tables associated with the default curves are shown on the next page.

Freeways

Freeway speed-flow curves provide a relationship between v/c ratio and free-flow speed.

Default speed-flow curves are provided for 2-lane, 4-lane, 6-lane or 8+-lane freeways with free-flow speeds of 50, 60, or 70 mph.

For freeways, if the user inputs a speed less than 50 mph, the software will default to the 50 mph freeway speed-flow curves. If the user inputs a speed greater than 70 mph, the software will default to the 70 mph freeway speed-flow curves.

Input speeds in between the allowable speeds will be rounded UP to the nearest allowable speed.

Arterials

The term “Arterial”, as used by WSDOT, applies to state highways in urban areas with no or limited signal controls.

Arterial speed-flow curves provide a relationship between v/c ratio and free-flow speed.

Default speed-flow curves are provided for two-lane or multi-lane arterials with free-flow speeds of 50 or 60 mph. The speed-flow curves for two-lane arterials are the same as those for the two-lane freeways.

For arterials, if the user inputs a speed less than or equal to 50 mph, the software will default to the 50 mph arterial speed-flow curves. If the user inputs a speed greater than 50 mph, the software will default to the 60 mph freeway speed-flow curves.

HOV Facilities

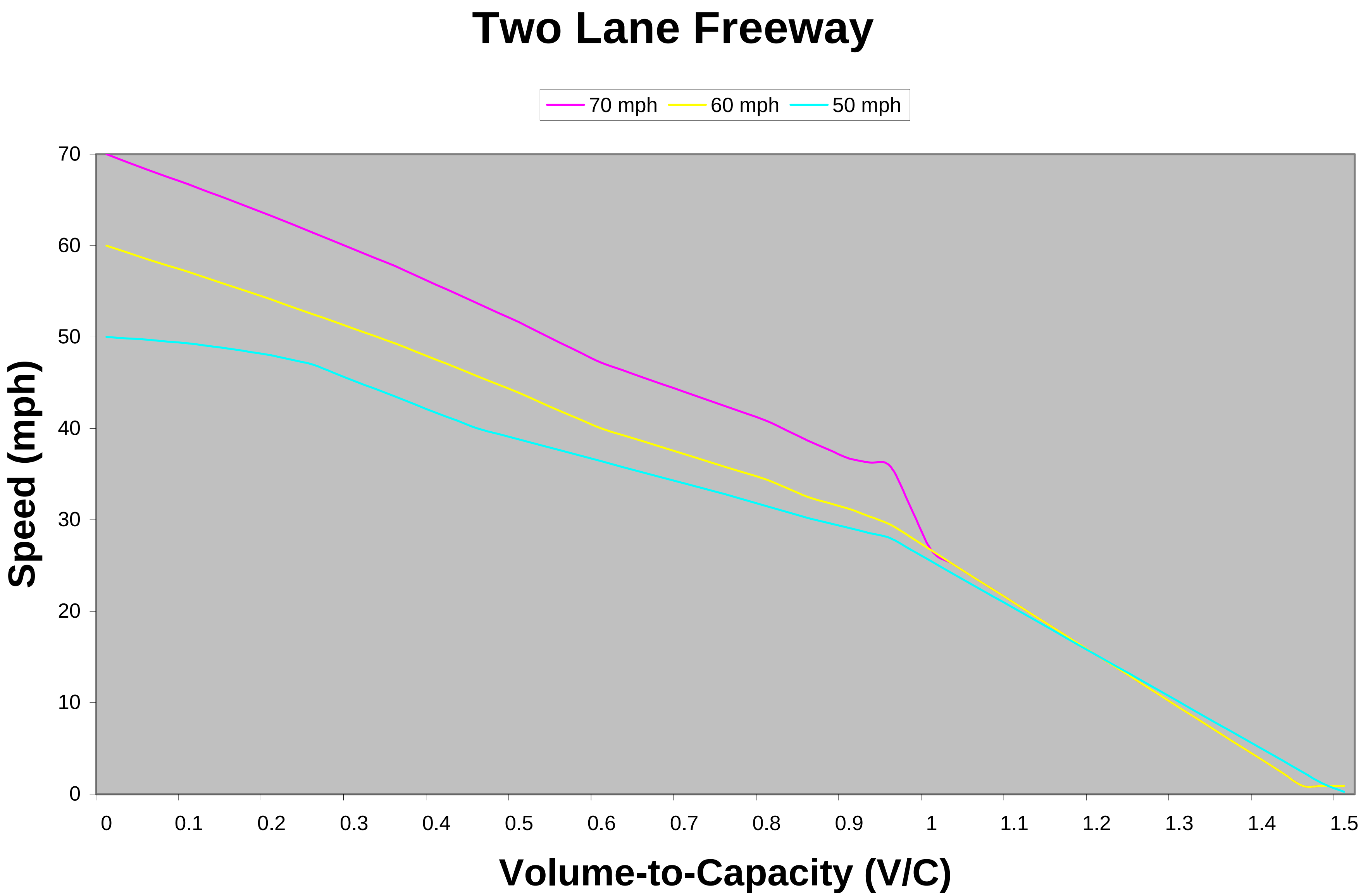
HOV speed-flow curves provide a direct relationship between speed and volume, assuming a capacity of 1,500 vphpl for HOV facilities.

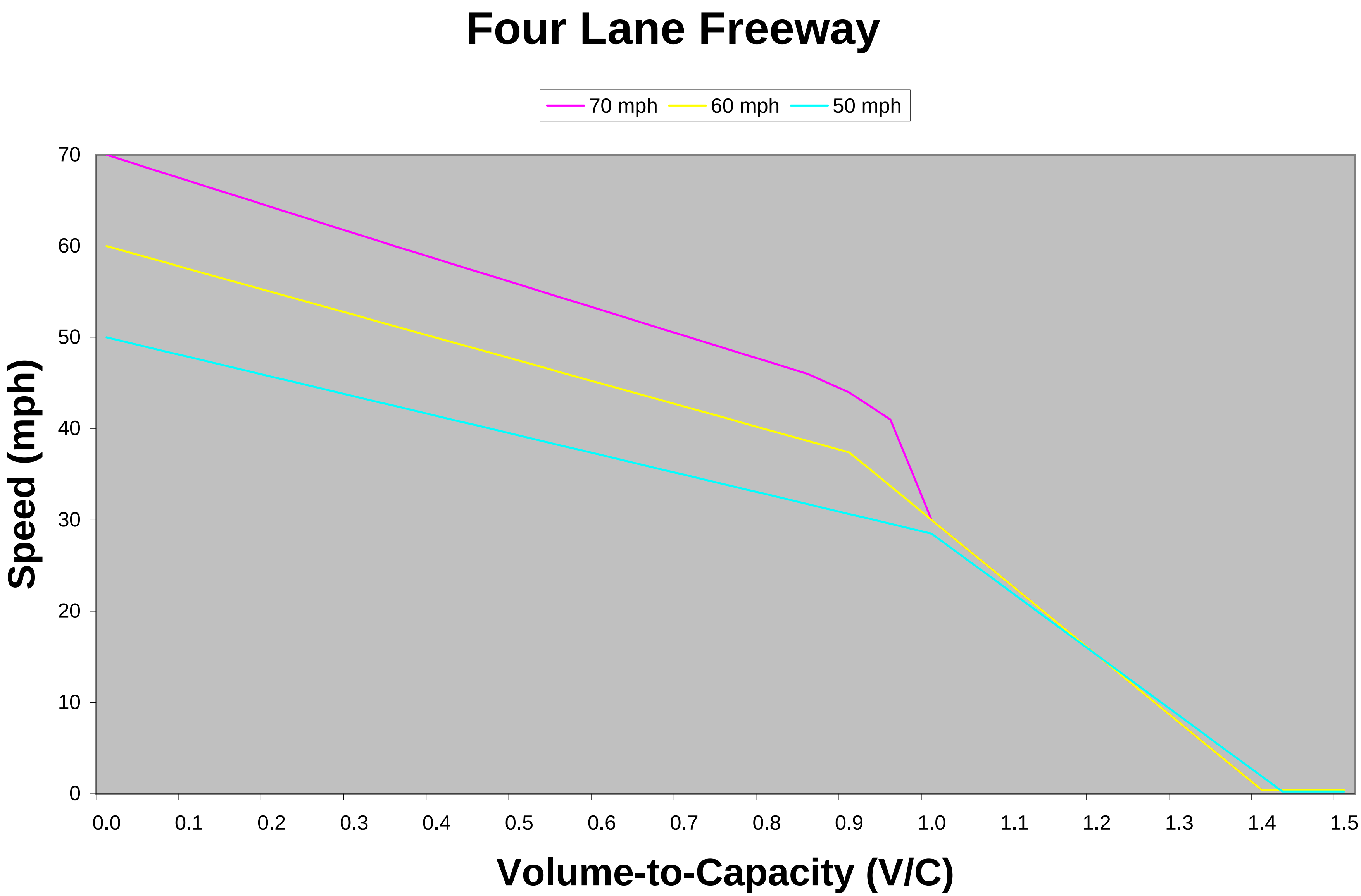
For the HOV lane analysis, the default free-flow speed in 55 mph. HOV speeds are assumed to never go below 40 mph.

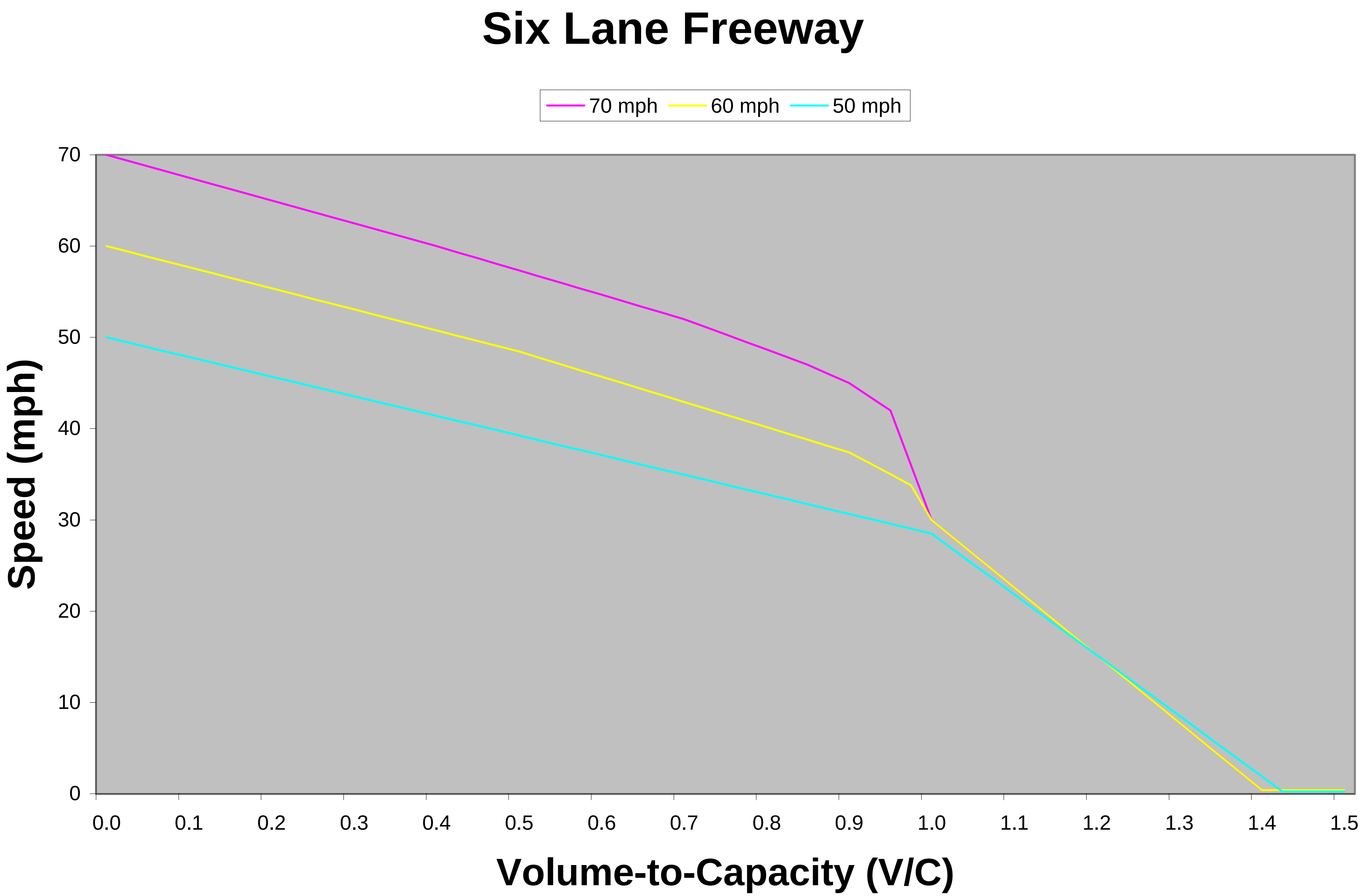
WSDOT DEFAULT SPEED-FLOW CURVES

V/C	70 MPH Freeway Curves					60 MPH Freeway Curves					50 MPH Freeway Curves					60 MPH Arterial				50 MPH Arterial			
	2 Lanes	4 Lanes	6 Lanes	8 Lanes	10 Lanes	2 Lane	4 Lanes	6 Lanes	8 Lanes	10 Lanes	2 Lane	Multilane				2 Lane	Multilane			2 Lane	Multilane		
0.000	70.0	70.0	70.0	70.0	70.0	60.0	60.0	60.0	60.0	60.0	50.0	50.0	50.0	50.0	50.0	60.0	60.0	60.0	60.0	50.0	50.0	50.0	50.0
0.025	69.1	69.3	69.4	69.5	69.5	59.3	59.4	59.4	59.5	59.5	49.9	49.5	49.5	49.5	49.5	59.3	59.3	59.3	59.3	49.9	49.4	49.4	49.4
0.050	68.3	68.6	68.8	68.9	68.9	58.5	58.7	58.8	58.9	58.9	49.7	48.9	48.9	48.9	48.9	58.5	58.5	58.5	58.5	49.7	48.9	48.9	48.9
0.075	67.5	67.9	68.1	68.4	68.4	57.8	58.1	58.3	58.4	58.4	49.5	48.4	48.4	48.4	48.4	57.8	57.8	57.8	57.8	49.5	48.3	48.3	48.3
0.100	66.7	67.1	67.5	67.8	67.8	57.1	57.5	57.7	57.8	57.8	49.3	47.9	47.9	47.9	47.9	57.1	57.0	57.0	57.0	49.3	47.7	47.7	47.7
0.125	65.8	66.4	66.9	67.3	67.3	56.4	56.9	57.1	57.3	57.3	49.0	47.3	47.3	47.3	47.3	56.4	56.3	56.3	56.3	49.0	47.1	47.1	47.1
0.150	65.0	65.7	66.3	66.7	66.7	55.6	56.2	56.5	56.7	56.7	48.7	46.8	46.8	46.8	46.8	55.6	55.5	55.5	55.5	48.7	46.6	46.6	46.6
0.175	64.1	65.0	65.6	66.2	66.2	54.9	55.6	56.0	56.2	56.2	48.4	46.2	46.2	46.2	46.2	54.9	54.8	54.8	54.8	48.4	46.0	46.0	46.0
0.200	63.3	64.3	65.0	65.6	65.6	54.1	55.0	55.4	55.7	55.7	48.0	45.7	45.7	45.7	45.7	54.1	54.0	54.0	54.0	48.0	45.4	45.4	45.4
0.225	62.3	63.6	64.4	65.1	65.1	53.3	54.4	54.8	55.1	55.1	47.5	45.2	45.2	45.2	45.2	53.3	53.3	53.3	53.3	47.5	44.8	44.8	44.8
0.250	61.4	62.9	63.8	64.5	64.5	52.5	53.7	54.2	54.6	54.6	47.0	44.6	44.6	44.6	44.6	52.5	52.5	52.5	52.5	47.0	44.3	44.3	44.3
0.275	60.5	62.1	63.1	64.0	64.0	51.7	53.1	53.6	54.0	54.0	46.1	44.1	44.1	44.1	44.1	51.7	51.8	51.8	51.8	46.1	43.7	43.7	43.7
0.300	59.6	61.4	62.5	63.4	63.4	50.9	52.5	53.1	53.5	53.5	45.2	43.6	43.6	43.6	43.6	50.9	51.0	51.0	51.0	45.2	43.1	43.1	43.1
0.325	58.7	60.7	61.9	62.9	62.9	50.1	51.8	52.5	53.0	53.0	44.4	43.0	43.0	43.0	43.0	50.1	50.3	50.3	50.3	44.4	42.5	42.5	42.5
0.350	57.8	60.0	61.3	62.3	62.3	49.3	51.2	51.9	52.4	52.4	43.5	42.5	42.5	42.5	42.5	49.3	49.5	49.5	49.5	43.5	42.0	42.0	42.0
0.375	56.7	59.3	60.6	61.8	61.8	48.4	50.6	51.3	51.9	51.9	42.6	41.9	41.9	41.9	41.9	48.4	48.8	48.8	48.8	42.6	41.4	41.4	41.4
0.400	55.7	58.6	60.0	61.2	61.2	47.5	50.0	50.8	51.3	51.3	41.7	41.4	41.4	41.4	41.4	47.5	48.0	48.0	48.0	41.7	40.8	40.8	40.8
0.425	54.7	57.9	59.3	60.7	60.7	46.6	49.3	50.2	50.8	50.8	40.9	40.9	40.9	40.9	40.9	46.6	47.3	47.3	47.3	40.9	40.2	40.2	40.2
0.450	53.7	57.2	58.7	60.1	60.1	45.7	48.7	49.6	50.2	50.2	40.0	40.3	40.3	40.3	40.3	45.7	46.5	46.5	46.5	40.0	39.7	39.7	39.7
0.475	52.6	56.5	58.0	59.4	59.4	44.8	48.1	49.0	49.7	49.7	39.4	39.8	39.8	39.8	39.8	44.8	45.8	45.8	45.8	39.4	39.1	39.1	39.1
0.500	51.6	55.8	57.3	58.6	58.6	43.9	47.4	48.5	49.2	49.2	38.8	39.3	39.3	39.3	39.3	43.9	45.0	45.0	45.0	38.8	38.5	38.5	38.5
0.525	50.5	55.1	56.7	57.9	57.9	42.9	46.8	47.8	48.4	48.4	38.2	38.7	38.7	38.7	38.7	42.9	44.3	44.3	44.3	38.2	37.9	37.9	37.9
0.550	49.3	54.4	56.0	57.1	57.1	41.9	46.2	47.1	47.7	47.7	37.6	38.2	38.2	38.2	38.2	41.9	43.5	43.5	43.5	37.6	37.4	37.4	37.4
0.575	48.3	53.7	55.3	56.4	56.4	41.0	45.6	46.4	47.0	47.0	37.0	37.6	37.6	37.6	37.6	41.0	42.8	42.8	42.8	37.0	36.8	36.8	36.8
0.600	47.2	53.0	54.7	55.6	55.6	40.0	44.9	45.7	46.2	46.2	36.4	37.1	37.1	37.1	37.1	40.0	42.0	42.0	42.0	36.4	36.2	36.2	36.2
0.625	46.4	52.3	54.0	54.9	54.9	39.3	44.3	45.0	45.5	45.5	35.8	36.6	36.6	36.6	36.6	39.3	41.3	41.3	41.3	35.8	35.6	35.6	35.6
0.650	45.6	51.6	53.3	54.1	54.1	38.6	43.7	44.3	44.8	44.8	35.2	36.0	36.0	36.0	36.0	38.6	40.5	40.5	40.5	35.2	35.1	35.1	35.1
0.675	44.8	50.9	52.7	53.4	53.4	37.9	43.1	43.6	44.0	44.0	34.6	35.5	35.5	35.5	35.5	37.9	39.8	39.8	39.8	34.6	34.5	34.5	34.5
0.700	44.0	50.2	52.0	52.8	52.8	37.2	42.4	42.9	43.3	43.3	34.0	35.0	35.0	35.0	35.0	37.2	39.0	39.0	39.0	34.0	33.9	33.9	33.9
0.725	43.2	49.5	51.2	52.1	52.1	36.5	41.8	42.2	42.5	42.5	33.4	34.4	34.4	34.4	34.4	36.5	38.3	38.3	38.3	33.4	33.3	33.3	33.3
0.750	42.4	48.8	50.3	51.4	51.4	35.8	41.2	41.5	41.8	41.8	32.8	33.9	33.9	33.9	33.9	35.8	37.5	37.5	37.5	32.8	32.8	32.8	32.8
0.775	41.6	48.1	49.5	50.8	50.8	35.1	40.5	40.9	41.1	41.1	32.2	33.3	33.3	33.3	33.3	35.1	36.8	36.8	36.8	32.2	32.2	32.2	32.2
0.800	40.8	47.4	48.7	50.1	50.1	34.4	39.9	40.2	40.3	40.3	31.5	32.8	32.8	32.8	32.8	34.4	36.0	36.0	36.0	31.5	31.6	31.6	31.6
0.825	39.8	46.7	47.8	49.1	49.1	33.5	39.3	39.5	39.6	39.6	30.9	32.3	32.3	32.3	32.3	33.5	35.3	35.3	35.3	30.9	31.0	31.0	31.0
0.850	38.7	46.0	47.0	48.1	48.1	32.5	38.7	38.8	38.9	38.9	30.2	31.7	31.7	31.7	31.7	32.5	34.5	34.5	34.5	30.2	30.5	30.5	30.5
0.875	37.7	45.0	46.0	47.1	47.1	31.9	38.0	38.1	38.1	38.1	29.7	31.2	31.2	31.2	31.2	31.9	33.8	33.8	33.8	29.7	29.9	29.9	29.9
0.900	36.7	44.0	45.0	46.1	46.1	31.2	37.4	37.4	37.4	37.4	29.1	30.7	30.7	30.7	30.7	31.2	33.0	33.0	33.0	29.1	29.3	29.3	29.3
0.925	36.3	42.5	43.5	44.6	44.6	30.4	35.6	36.2	36.2	36.2	28.6	30.1	30.1	30.1	30.1	30.4	32.3	32.3	32.3	28.6	28.7	28.7	28.7
0.950	35.9	41.0	42.0	43.1	43.1	29.5	33.7	35.0	35.0	35.0	28.0	29.6	29.6	29.6	29.6	29.5	31.5	31.5	31.5	28.0	28.2	28.2	28.2
0.975	31.3	35.5	36.0	36.6	36.6	28.1	31.9	33.8	33.8	33.8	26.7	29.0	29.0	29.0	29.0	28.1	30.8	30.8	30.8	26.7	27.6	27.6	27.6
1.000	26.6	30.0	30.0	30.0	30.0	26.6	30.0	30.0	30.0	30.0	25.4	28.5	28.5	28.5	28.5	26.6	30.0	30.0	30.0	25.4	27.0	27.0	27.0
1.025	25.2	28.2	28.2	28.2	28.2	25.2	28.2	28.2	28.2	28.2	24.2	26.8	26.8	26.8	26.8	25.2	28.2	28.2	28.2	24.2	25.5	25.5	25.5
1.050	23.8	26.3	26.3	26.3	26.3	23.8	26.3	26.3	26.3	26.3	22.9	25.2	25.2	25.2	25.2	23.8	26.3	26.3	26.3	22.9	24.1	24.1	24.1
1.075	22.3	24.5	24.5	24.5	24.5	22.4	24.5	24.5	24.5	24.5	21.6	23.5	23.5	23.5	23.5	22.4	24.5	24.5	24.5	21.6	22.6	22.6	22.6
1.100	20.9	22.6	22.6	22.6	22.6	20.9	22.6	22.6	22.6	22.6	20.3	21.9	21.9	21.9	21.9	20.9	22.6	22.6	22.6	20.3	21.1	21.1	21.1
1.125	19.5	20.8	20.8	20.8	20.8	19.5	20.8	20.8	20.8	20.8	19.0	20.2	20.2	20.2	20.2	19.5	20.8	20.8	20.8	19.0	19.6	19.6	19.6
1.150	18.1	18.9	18.9	18.9	18.9	18.1	18.9	18.9	18.9	18.9	17.8	18.5	18.5	18.5	18.5	18.1	18.9	18.9	18.9	17.8	18.2	18.2	18.2
1.175	16.6	17.1	17.1	17.1	17.1	16.6	17.1	17.1	17.1	17.1	16.5	16.9	16.9	16.9	16.9	16.6	17.1	17.1	17.1	16.5	16.7	16.7	16.7
1.200	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
1.225	13.8	13.4	13.4	13.4	13.4	13.8	13.4	13.4	13.4	13.4	13.9	13.5	13.5	13.5	13.5	13.8	13.4	13.4	13.4	13.9	13.7	13.7	13.7
1.250	12.3	11.5	11.5	11.5	11.5	12.3	11.5	11.5	11.5	11.5	12.6	11.9	11.9	11.9	11.9	12.3	11.5	11.5	11.5	12.6	12.3	12.3	12.3
1.275	10.9	9.7	9.7	9.7	9.7	10.9	9.7	9.6	9.6	9.6	11.4	10.2	10.2	10.2	10.2	10.9	9.7	9.7	9.7	11.4	10.8	10.8	10.8
1.300	9.5	7.8	7.8	7.8	7.8	9.5	7.8	7.8	7.8	7.8	10.1	8.6	8.6	8.6	8.6	9.5	7.8	7.8	7.8	10.1	9.3	9.3	9.3
1.325	8.0	6.0	6.0	6.0	6.0	8.1	6.0	5.9	5.9	5.9	8.8	6.9	6.9	6.9	6.9	8.1	6.0	6.0	6.0	8.8	7.8	7.8	7.8
1.350	6.6	4.1	4.1	4.1	4.1	6.6	4.1	4.1	4.1	4.1	7.5	5.2	5.2	5.2	5.2	6.6	4.1	4.1	4.1	7.5	6.4	6.4	6.4
1.375	5.2	2.3	2.3	2.3	2.3	5.2	2.3	2.2	2.2	2.2	6.2	3.6	3.6	3.6	3.6	5.2	2.3	2.3	2.3	6.2	4.9	4.9	4.9
1.400	3.8	0.4	0.4	0.4	0.4	3.8	0.4	0.4	0.4	0.4	5.0	1.9	1.9	1.9	1.9	3.8	0.4	0.4	0.4	5.0	3.4	3.4	3.4
1.425	2.3	0.4	0.4	0.4	0.4	2.3	0.4	0.4	0.4	0.4	3.7	0.2	0.2	0.2	0.2	2.3	0.4	0.4	0.4	3.7	1.9	1.9	1.9
1.450	0.9	0.4	0.4	0.4	0.4	0.9	0.4	0.4	0.4	0.4	2.4	0.2	0.2	0.2	0.2	0.9	0.4	0.4	0.4	2.4	0.5	0.5	0.5
1.475	0.9	0.4	0.4	0.4	0.4	0.9	0.4	0.4	0.4	0.4	1.1	0.2	0.2	0.2	0.2	0.9	0.4	0.4	0.4	1.1	0.5	0.5	0.5
1.500	0.9	0.4	0.4	0.4	0.4	0.9	0.4	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.9	0.4	0.4	0.4	0.2	0.5	0.5	0.5

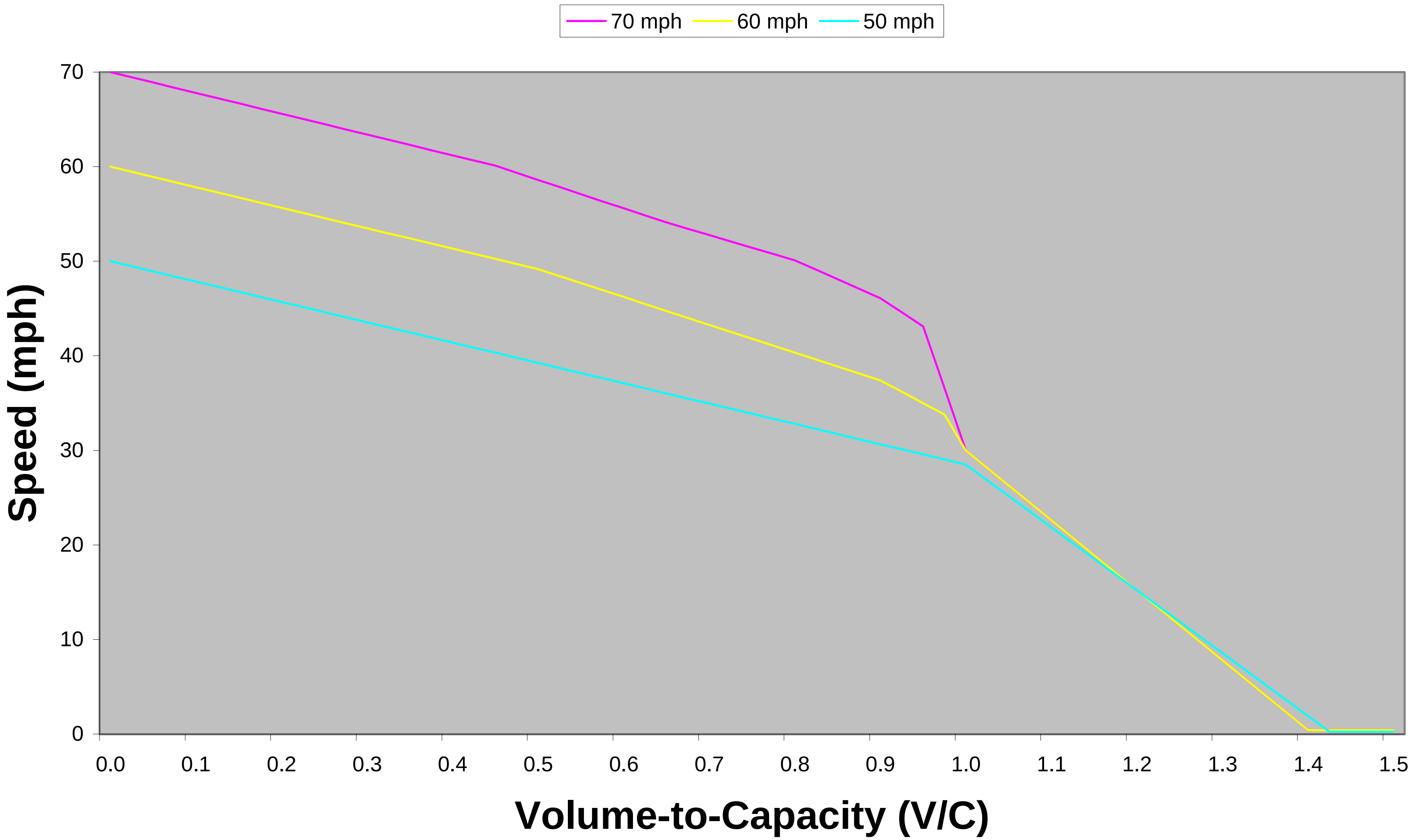
HOV Lane	
Volume	Speed
0	55.0
50	55.0
100	55.0
150	55.0
200	55.0
250	55.0
300	55.0
350	55.0
400	55.0
450	55.0
500	55.0
550	55.0
600	55.0
650	55.0
700	55.0
750	55.0
800	55.0
850	55.0
900	55.0
950	55.0
1000	55.0
1050	54.0
1100	54.0
1150	54.0
1200	53.0
1250	53.0
1300	53.0
1350	52.0
1400	48.0
1450	45.0
1500	40.0
1550	40.0
1600	40.0
1650	40.0
1700	40.0
1750	40.0

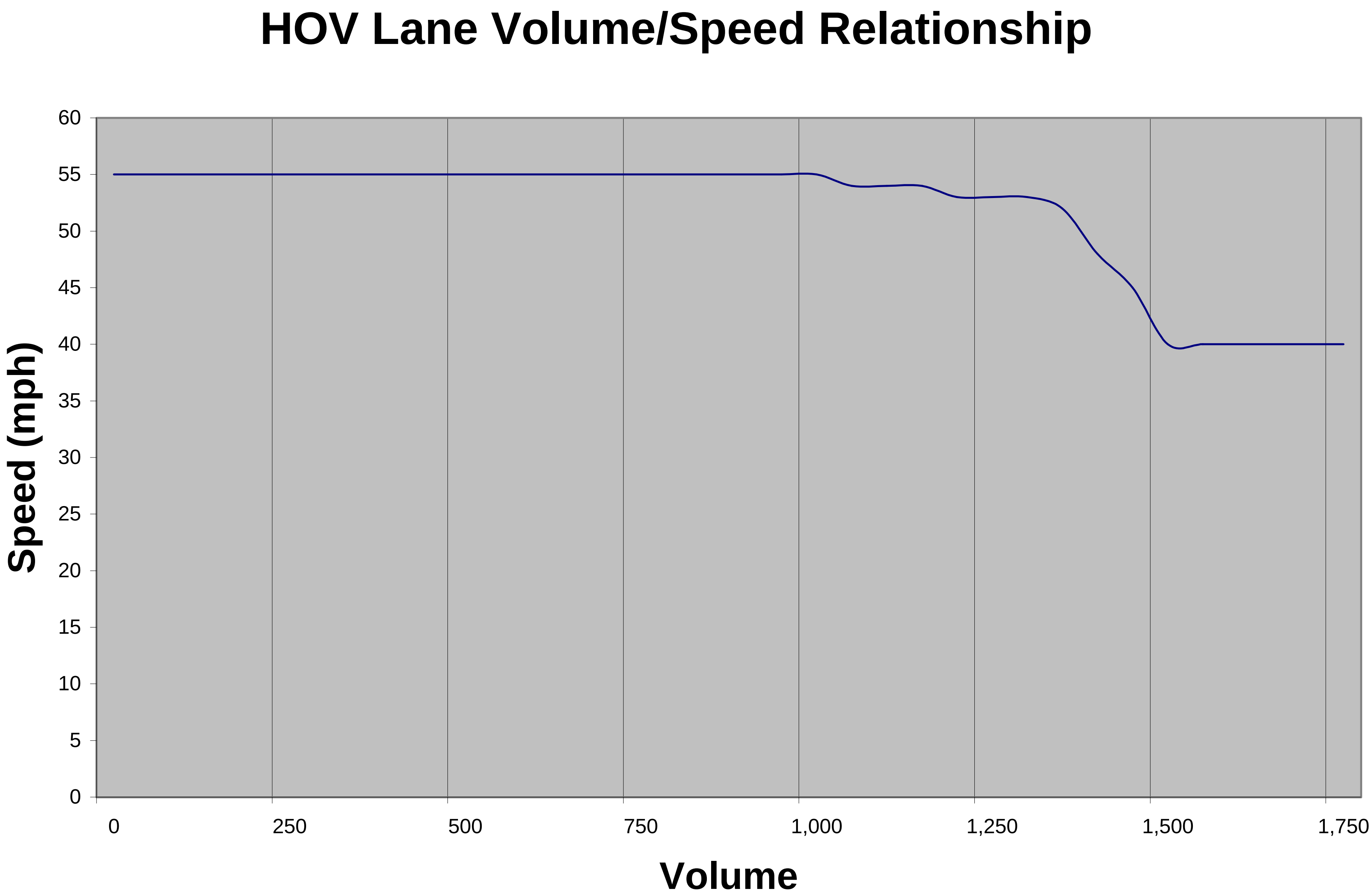

Two Lane Freeway
70 mph
60 mph
50 mph
Speed (mph)
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
Volume-to-Capacity (V/C)


Four Lane Freeway
70 mph
60 mph
50 mph
Speed (mph)
70
60
50
40
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Volume-to-Capacity (V/C)


Six Lane Freeway
70 mph
60 mph
50 mph
Speed (mph)
70
60
50
40
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
Volume-to-Capacity (V/C)

Eight-plus Lane Freeway




HOV Lane Volume/Speed Relationship
Speed (mph)
60
55
50
45
40
35
30
25
20
15
10
5
0
0
250
500
750
1,000
1,250
1,500
1,750
Volume

HCM 2000 Speed-Flow Curves

The WSDOT software speed-flow curves are based upon data that is 30 years old. More recent data presented in the Draft Year 2000 Highway Capacity Manual confirms that while the WSDOT software speed-flow curves for two lane highways are still accurate, the curves for the remaining facility types (freeways, multi-lane highways, and arterials) no longer accurately reflect how drivers respond to increasing traffic congestion.

The Year 2000 update of the MPPPbc software allows users the option of selecting the HCM 2000 speed-flow curves in the HOV Lane worksheet for computing the benefits of adding an HOV lane to a freeway.

Comparison of WSDOT Tables to 1997 Highway Capacity Manual

The following figures compare the WSDOT speed flow curves to the 1997 Highway Capacity Manual (HCM) speed-flow curves for freeways for v/c ratios less than or equal to 1.0. As shown, the WSDOT default curves drop rapidly compared to the HCM curves for v/c ratios below 1.00.

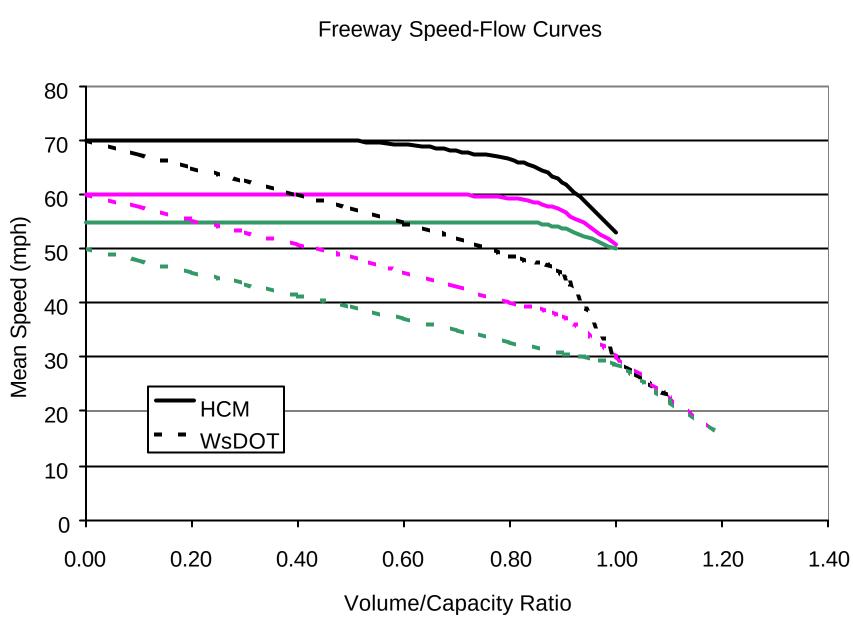


Figure 21. Comparison of WSDOT and HCM Curves for Freeways

Fitted Speed-flow Curve Equations

As part of research for the Year 2000 Highway Capacity Manual, the Akçelik[6] equation was reviewed as a potential tool for predicting mean vehicle speeds as a function of the link volume/capacity ratio. The Akçelik equation has since been updated and re-calibrated to match the Year 2000 Highway Capacity Manual speed-flow curves for freeways, multi-lane highways, two lane highways, and signalized arterial streets.

General Akçelik Equation

Using the Akçelik equation to compute link traversal time, the mean vehicle speed for a link is estimated by dividing the link length by the link traversal time.

The link traversal time (R) is computed according to the following modified Akçelik equation:

$$R = R_0 + D_0 + D_L + 0.25N*T\left[(x-1)+\sqrt{(x-1)^2+\frac{16J \bullet L^2 \bullet x}{N^2T^2}}\right]$$

where:

R = segment traversal time (hr)

Ro = segment traversal time at free-flow speed (hr)

Do = Zero-flow control delay at signals (equals zero if no signals) (hr)

DL = Segment delay between signals (equals zero if no signals) (hr)

N = the number of signals on the segment (if no signals, set N = 1)

T = the expected duration of the demand (typically one hour) (hr)

x = the segment demand/capacity ratio

L= the segment length (miles)

J = the calibration parameter

[6] The Akçelik equation was first presented in Road and Transport Research, "Accuracy and Performance of Improved Speed-Flow Curves", June 1998, and later in the Transportation Research Record 1646 (1998).

The segment traversal time for free-flow conditions (Ro) is computed from the free-flow speed.

$$R_0 = L / S_0$$

where:

Ro = free-flow traversal time (hr)

L = length (miles)

So = the segment free-flow speed (mph)

Akçelik Equation for Freeways

For freeways, where the number of signals equals zero and, therefore, the control delay at signals and the segment delay between signals also equals zero, the following equation can be used to predict link traversal travel times:

$$R = R_0 + 0.25 * T\left[(x-1) + \sqrt{(x-1)^2 + \frac{16J \bullet L^2 \bullet x}{T^2}}\right]$$

The recommended traversal time "J" parameters for freeways are shown in the following table:

Table 9. Akçelik Equation "J" Parameters

Free-Flow Speed (mph)	**Speed (mph) at Capacity**	**"J"**
75	54	1.05E-05
70	53	8.20E-06
65	52	5.78E-06
60	51	3.38E-06
55	50	1.29E-06

Comparison of Akçelik Equation and 2000 Highway Capacity Manual

The following figure shows the fit of the Akçelik equation with the 2000 Highway Capacity Manual (HCM) speed-flow curves for freeways.

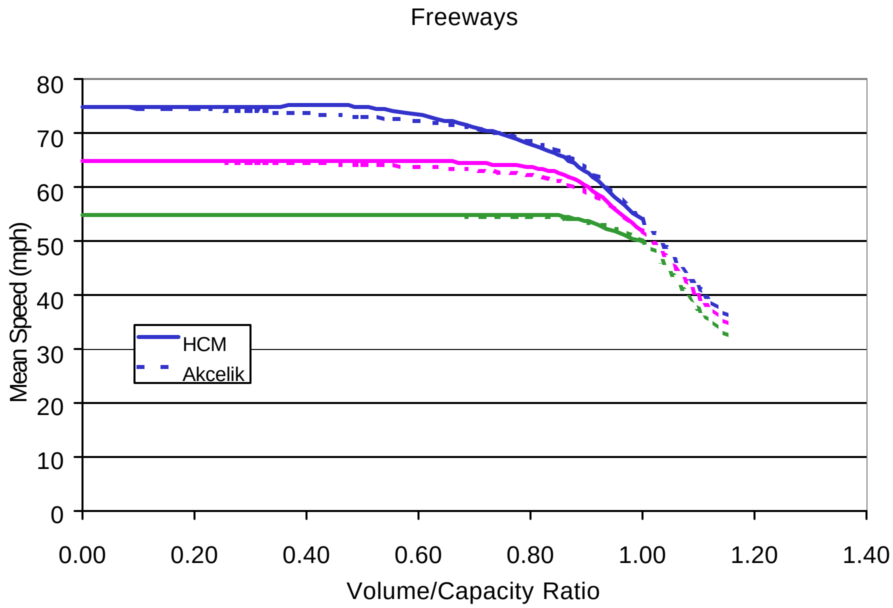


Figure 22. Comparison of Highway Capacity Manual and Akçelik Equation

Future Software Improvements

This section presents a list of potential improvements that may be considered for future updates of the MPPPbc software. The software improvements listed here were deferred to the long term either because they are likely to have little effect on the performance of the WSDOT software or because of various difficulties involved in implementing them within the time frame of the Year 2000 software update research project. Note that the future enhancements listed here are grouped by type of improvement, but are in no particular order within each grouping. No priority has been recommended.

Demand Forecasting Methodology

Induced Demand

It is recommended that the WSDOT spreadsheets incorporate an elasticity model of the type used in FHWA's HERS software to account for the demand increasing effect of highway capacity improvement projects. This option would reflect potential induced demand, and would only be used in the absence of a better estimate from a metropolitan area travel demand model. This would allow analysts to incorporate better estimates of future demand for the project, where such information is available.

Peak Hour Spreading

The current peak spreading method contained in the WSDOT software needs to be re-evaluated in light of recent research on system-wide and facility specific peak spreading. Recent research indicates several potential difficulties with the current approach but does not provide good guidance on what should be substituted in place of the current approach.

The current method assumes that all excess demand (greater than 120% of capacity) is shifted to earlier hours (if before 5 PM) and to later hours (if after 5 PM). In reality, some of this excess demand will shift to other routes, and other modes, although the amount of this shift is still poorly understood at this time.

The assumptions behind the current peak spreading algorithm also tend to breakdown for exceedingly unrealistic demand forecasts (peak spreading to 3 AM in the morning for example). There is, as yet, no consensus in the travel modeling community as to how to deal with excessive peak spreading caused by unrealistic demand forecasts. A warning to the user may be appropriate in these situations.

The WSDOT software benefit computations do not currently take into account the disbenefits of shifting trips to less desirable hours of the day. A value for time shifted (rather than delayed) trips would need to be developed to incorporate this peak spreading effect into the benefit computations.

Develop Park and Ride Demand Model

Instead of assuming that park and ride lots are full the first year after completion, WSDOT may wish to incorporate a park and ride demand estimation model. The available demand estimation models for park and ride lots are still quite crude. The best available method is to employ a four step area-wide travel demand model, however; even these models are not highly accurate at the level of zonal detail needed to evaluate potential park and ride lots.

HOV Lane and Park & Ride Lot Double Counting

The HOV spreadsheet assumes that the percentage of HOVs on a facility will increase over time. If part of this increase is due to the construction of park & ride lots along the facility, then user benefits are being double-counted between the two spreadsheets. If the HOV growth factor is retained, then the analyst should clearly identify what factors were assumed in the development of the growth factor. If park & ride lots are one of these factors, then the travel time portion of the park & ride lot benefit calculation should not be used when calculating the additional benefits of these lots.

Better Define Park & Ride Users

The park and ride worksheet should provide user inputs for the percent of users who are new transit riders, the percent of users who are new carpoolers, and the percent of users arriving from the freeway. The benefits for each type of user are somewhat different, so the number of users of each type must be known.

Travel Time Savings Estimation

Allocation of HOVs to Mixed Flow Lanes

The FHWA QUICK-HOV equation for allocating a percentage HOV’s to the HOV lanes according to the amount of time saved would improve the accuracy of the travel time savings predicted for HOV lanes. However, the allocation of 100% of HOV’s to the HOV lanes is not considered to be a large source of error in the current benefit estimation approach.

Capacity Estimation

WSDOT may wish to add the HCM 1997 capacity estimation procedures described above instead of using the capacity defaults. This may be even more important if WSDOT is eventually interested in extending the mobility programming spreadsheets to the analysis of intelligent transportation system (ITS) and other capacity enhancing options.

Climbing Lane Worksheet

A cursory review of the travel time equations in the Climbing Lane worksheet found that under certain conditions, the travel times for cars only can be longer than travel times for cars and trucks. This may be a legitimate outcome of the assumptions upon which this worksheet is based, but it may be worth investigating and documenting this for future users.

Benefits Computation

Value of In-Vehicle Time as % of Wage Rate

In April 1997, the U.S. Department of Transportation published a guide for the valuation of travel time for use by all federal agencies when conducting economic analysis. The memo addresses the theoretical underpinnings for valuing travel, reviews the recent empirical studies, and recommends appropriate values for use in project evaluation. In this memo, the recommended percentages of wage rates for value of time is 50% for personal auto use and 100% for business auto use.

In the MPPPbc software, the value of in-vehicle time for auto use defaults to 33% of the average wage rate. WSDOT may want to consider changing the default rate in future software updates.

Enable Subsection Analysis of Projects

The spreadsheets would be modified to allow the analyst to enter demand and capacity data for subsections of a project. The spreadsheet would accumulate the costs and benefits for each subsection and report the results for the entire project.

Investigation of Negative Benefits in INTBEN

The interchange analysis worksheet (INTBEN can produce negative project benefits under certain demand situations. This may be a legitimate result of the assumptions used in the analysis, it may be worth investigating and documenting for future users. Perhaps warnings to the user about such situations should be included.

Environmental Benefits

WSDOT may wish to add the ability to include environmental retrofit benefits in the MPPPbc software in future updates.

Inflation Factor

WSDOT may wish to add the ability for users to inflate (or deflate) project cost estimates from a specified year to a specified year. This feature could be added to the B/C estimate sheet.

Acknowledgments

This software update is the collective work of many contributors. Dowling Associates reviewed the WSDOT benefit / cost methodology and performed most of the software updates. ECONorthwest provided input on the value of time and cost parameters. Kittelson & Associates updated the two-way-left-turn-lane and park & ride analyses. Rao Associates surveyed users of the original software and beta tested the updated software.

The Dowling Associates consultant team would like to thank a couple of WSDOT participants without whom we could not have performed this software update. As Technical Monitor, Mr. Pat Morin of the WSDOT Program Management Office provided invaluable guidance and input. Mr. Gary Westby of the Southwest Region was a primary contributor of the original benefit/cost estimate software and he and his staff (Kevin Miller, Craig Helmann and Erin Gardner) reviewed and tested the beta software. We conclude by thanking the members of the mobility technical advisory committee for their advice and assistance on this project.

WSDOT Project Manager

Pat Morin, WSDOT Program Management Office

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